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ABSTRACT

This first volume of a comprehensive curriculum guide for the heating-ventilation-air conditioning-refrigeration-solar student is designed to assist high school area vocational centers or community college instructors in the implementation and operation of comfort training programs. Following an introductory section, the guide provides job competencies, including minimum entry level, and career ladder advancement procedures. Additional sections describe how to use the solar energy installers curriculum guide and provide reference materials. The remainder of the guide is comprised of eighteen units of instruction within four major areas: solar application installation, electrical, backup heating systems, and refrigeration theory. Presented for each unit are unit numbers, instructional objective, reference materials: audio visual materials available, outline, performance conditions, student evaluation criteria, procedure of instituting unit, unit tests, and exams. (LRA)

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ED189390

SOLAR ENERGY INSTALLERS CURRICULUM GUIDES

FUNDING AGREEMENT #R-33-10-X-0442-316

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Technology Subdivision
Air Conditioning-Refrigeration-Heating Department
College of DuPage
Glen Ellyn, Illinois

Sponsored by:

STATE BOARD OF EDUCATION
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DEPARTMENT OF ADULT, VOCATIONAL, AND TECHNICAL EDUCATION

Springfield, Illinois

June 1980

CE 025 923

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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DISCLAIMER

The Solar Energy Installers Curriculum Guides, R-33-10-X-0442-316, was developed pursuant to a funding agreement with the Illinois Office of Education/Department of Adult, Vocational and Technical Education/ Research and Development Section, 100 North First Street, Springfield, Illinois 62777. Opinions expressed in this guide do not reflect, nor should they be construed as policy or opinion of the State Board of Education/Illinois Office of Education or its staff.

FOREWORD

The College of DuPage, Technology Division, Air Conditioning/ Refrigeration Department, is pleased to present: SOLAR ENERGY INSTALLERS CURRICULUM GUIDES.

These guides were developed to be used as a basis to develop a Competency-Based Solar Energy Education Program for the training of individuals needed for the installation of solar energy equipment.

A special thanks to Richard R. Miller, Director of Development, for his assistance and advice; Patricia Polonus for sharing her typing skills; and Lucille Edwards for her assistance in literature searches through our Learning Resources Center.

CURRICULUM MATERIALS ABSTRACT

Title of Materials: Solar Energy Installer Curriculum Guides

Date Materials Developed: September 1979 - June 1980

Date Abstract Prepared: June 1980

Name of Developer: Gene C. Walker
College of DuPage

Through contractual agreement with the Illinois State Board of Education, Department of Adult, Vocational, and Technical Education

Key Word Index: Comfort Industry Solar

Type of Materials: Occupational Education
Paper Bound

For Student Use: Regular, Disadvantaged

Target Level of Students: 11-12, 12-14, adult

For Professional Use: Classroom teacher

Is Training Required for Optimum Use of These Materials: Yes

Are Consulting Services Available: Yes, Illinois Solar Energy Directors Section 5

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Available from College of DuPage
HVAC Department

ABSTRACT

The publication is a comprehensive curriculum guide for the Heating-Ventilation-Air Conditioning-Refrigeration-Solar student. It is designed to assist high school area vocation centers or community college instructors in the implementation and operation of comfort training programs. Included are job competencies, including minimum entry level, career ladder advancement procedures. Suggested sequence of units. Presented are unit numbers, instructional objective, reference materials, audio visual materials available, outline, performance conditions, student evaluation criteria, procedure of instituting unit, unit tests, and exams.

The areas listed in order are:

1. Solar Application Installation
2. HVACS Electrical
3. Backup Heating Systems
4. Refrigeration Theory
5. Refrigeration Service Procedures
6. Heat Transfer Methods and Systems

The publication was printed in 1980. The original was developed in a looseleaf form so that it could be easily updated and revised by inserting new pages.

ADVISORY BOARD OF REVIEW

UNDER COLLEGE OF DuPAGE'S TECHNOLOGY SUBDIVISION

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I. INTRODUCTION

A. Why Solar Energy

As we look at the ever-increasing cost of energy and lack of availability of fossil fuel, alternate energy sources become "necessity-mother of invention." Solar energy technology has existed for hundreds of years but expense was the main deterrent to its further development. In today's economy, cost is becoming less and less of a basis for decisions to go to an alternative energy source. Total lack of availability of cheap energy is fast becoming a reality, and those who have the foresight to develop alternate energies now and institute their use will be far ahead in the near future.

B. Solar Energy Technician

Needs for trained installers and service persons is a never-ending requirement for any mode of the Comfort Conditioning Industry.

Employment needs for solar energy technicians (SET's) were derived from (1) U.S. Department of Energy estimates of the current and projected number of solar homes in the United States; (2) the number of year-round housing units in Illinois; and (3) the average amount of time required to design, install and maintain solar space and water heating systems. The U.S. Department of Energy estimates that there are 40,000 solar homes in the United States at the present time and that there will be 2.5 million solar homes by 1985.[1] This represents an 80 per cent annual increase in the number of solar homes; by 1983 there will be approximately 750,000 solar homes in the country.

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[1] Research Institute Recommendations, Vol. 29, No. 33. New York: The Research Institute of America. August 18, 1978.

Illinois accounts for 5.5 per cent of the year-round housing units in the United States[2]. Assuming it is representative of the rest of the United States in its current and projected use of solar energy for home heating purposes, it was estimated that within Illinois there are currently 2183 solar homes and by 1983 there will be 41,250 solar homes in the State. During 1983, 18,333 solar heating systems will be installed in homes in Illinois.

To estimate the employment impact of this increase in the use of solar energy for home heating, figures from a Navarro College study of solar energy technology were used[3]. That study determined that the expected time required to design, install and maintain solar home heating systems was 10, 40, and 2 hours, respectively. The total design and installation time of 50 hours was divided into the number of work hours in a person-year (2080) in order to determine the number of solar heating systems that one SET could handle in a year (41.6). By dividing the number of systems that would be installed during the year 1983 (18,333) by the number of systems which one SET could design and install (41.6) an estimated 441 full-time SET's will be needed in 1983.

The number of SET positions which will be needed in 1983 in order to maintain the 41,250 solar heating systems was derived by multiplying the number of systems which will be in operation (41,250) by the number of hours per year required to maintain each system (2).

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2 Census of Housing, Vol. I. U.S. Bureau of the Census, 1970.

3 Navarro College, Assessment of Need for Developing and Implementing Technical and Skilled Worker Training For the Solar Energy Industry, Navarro College, Corsicana, Texas, January 1978.

This resulted in 82,500 SET hours needed for maintenance of systems in 1983. By dividing the number of hours required for maintenance (82,500) by the number of work hours in a person-year (2,080), it was estimated that an additional 40 full-time SET's will be needed to maintain solar heating systems. When added to the number of SET's required to design and install systems (441), a total of 481 SET's will be needed by 1983.

To estimate the growth from present SET employment, it was assumed that all of the 2,183 existing solar homes were built in 1978. The number of SET's required to design, install, and maintain the systems this year will be 55. Thus, the growth in SET employment from 1978 to 1983 is estimated to be 426.

The replacement rate for SET's was obtained by using the rate for plumbers and pipefitters, which is estimated to be 10 per cent over for the next five years[4]. This figure was applied to the 1978 SET employment of 55 to yield five additional positions needed due to replacements. Thus, the total growth and replacement needs for SET's between 1978-1983 is estimated to be 431.

The regional distribution of solar energy technicians in Illinois was assumed to follow that of plumbers and pipefitters. The figures used to estimate regional distribution of SET's is presented in Table 9.

Halfway House Residence Manager

The estimation of employment demand for HHRM was based on the assumptions that (1) halfway house growth would be positively related

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[4] Illinois Manpower Projections, op. cit.

to the present location of halfway houses, (2) the average tenure of HHRM's is two years, and (3) halfway houses would increase at the rate of ten per year. The number of halfway houses known to the state agencies contacted was 97. The replacement of the managers of these facilities would require 242 new HHRM's. Growth of halfway houses over the next five years would require 50 additional managers. It was further assumed that at least eight of these 50 managers would be replaced by 1983. Thus, the total number of openings for HHRM's by 1983 is estimated to be 300.

The regional estimates were based on the proportion of halfway houses presently within each region. The proportion of 72 halfway houses (for which addresses were readily available) within each region was multiplied by 300. This operation yielded the estimated demand for HHRM's by region. The regional estimation procedure is presented in Table 10.

Table 9

Derivation of Projected Five-Year Employment Requirements for Solar Energy Technician

Region	Plumbers/ Pipefitters	Percent of Total Employment	Total Demand (1978-1983)
1	1064	4.19	18
2	16305	64.14	276
3	401	1.58	7
4	655	2.58	11
5	316	1.24	5
6	1047	4.12	18
7	292	1.15	5
8	1069	4.21	18
9	260	1.02	4
10	527	2.07	9
11	811	3.19	14
12	184	0.72	3
13	1188	4.67	20
14	213	0.84	4
15	169	0.66	3
16	85	0.33	1
17	411	1.62	7
18	94	0.37	2
19	131	0.52	2
20	197	0.77	3
Total	25,419	100.00	431

Note: Rounding may cause discrepancies in totals.

Solar Energy Technician

Association of Plumbing, Heating, and Cooling Contractors, Inc., Rockford, Illinois

Century Solar Engineering, Bensonville, Illinois

Colorado State University, Fort Collins, Colorado

Illinois Association of Heating, Plumbing, and Cooling Contractors

Illinois Department of Business and Economic Development, Division of Energy, Springfield, Illinois

Illinois Institute of Technology, Chicago, Illinois

Oak Ridge Associated Universities; Manpower Education, Research and Training Division; Oak Ridge, Tennessee

Plumbers and Pipefitters Union, Local No. 99, Bloomington, Illinois

Solar Construction Company, Wood Dale, Illinois

Solar Division of International Harvester, Chicago, Illinois

Solar Dynamics, Northfield, Illinois

Solar Products, Rockford, Illinois

U. S. DOE, formerly Energy Research and Development Administration Office, Chicago, Illinois

U. S. DOE, Manpower Assessment Program; Education Programs Division; Washington, D.C.

II. CAREER LADDERS

A. Entry Level - novice, student beginning, apprentice, helper, stockperson, laborer

B. Infield Learning Level - second-year student, third-year apprentice, third-year laborer, counter sales, component person (one who deals with specific products only)

C. Semi-Skilled Level - certification degree-bearing student, fourth-year apprentice, in-house sales

D. Skilled Level - certificate or degree-bearing student with two years of field experience (total 4 years), journey person (fifth year in field), outside sales, technician

E. Specialist Level - on-site sales, on-site sizing, equipment and system design person, technical service, trouble-shooting person

F. Supervisory Level - foreperson lead person, customer service and sales representative (in-house level), inventory control person (computer), assistant manager

G. Management Level - owner of HVACS shop, contractor or subcontractor, business manager, sales manager, territorial manager or service manager, parent company, main mangement, board member

The Entry Level positions in HVACS field are considered to be set at a point where anyone with basic mathematical, scientific, drafting, construction, and mechanical aptitude could enter the field and advance beyond through training and experience.

The Infield Learning Level positions should be an integrated educational and practical experience for the individual. The person at this point should be in direct contact with persons in the more advanced levels. In order for a person to be promoted to Semi-Skilled, he or she must meet the following criteria:

1. Define basic HVACS terminology and describe theory of operation.
2. Demonstrate basic technical skill. (Work with hand-tools, motor capabilities, etc.)
3. Demonstrate ability to work with people.
4. Demonstrate ability to follow directions.
5. Demonstrate a willingness to advance to next level. (Some people enjoy being level-one personnel--"common laborer".)

The Semi-Skilled Level should be a very short period in the career flow-pattern. This is a final polishing and coordinating of all educational and practical experiences. In order for a person to advance from this level to skilled level, the following must be demonstrated:

1. Demonstrate ability to apply theory.
2. Demonstrate problem-solving capabilities.
3. Demonstrate ability to sell people using their knowledge and understanding of components used in the field.
4. Demonstrate ability to perform more complicated tasks without excessive supervision.
5. Successful completion of higher-level technical training.
6. Demonstrate specified duration and desire to move to next step.

The Skilled Level is equivalent in salary to an upper-middle-class income level. A person reaching this level may remain and exist quite comfortably. Anyone wishing to advance from this level must show definite drives in the following directions.

1. Demonstrate understanding of all HVACS (Heating, Ventilating, Air Conditioning, and Solar Systems.)
2. Demonstrate ability to diagnose electrical, piping, equipment problems.
3. Demonstrate ability to satisfactorily complete a task without any supervision.
4. Demonstrate desire to take charge and move into next level.

The Specialist Level is where a person who has shown exceptional skill in a particular area, plus understanding of all other levels, can receive additional monitary and mental satisfaction for his or her expertise. Advancement from this level to Supervisory Level can be achieved by the following:

1. Demonstrate ability to analyze difficult situations critically.
2. Demonstrate ability in specific technical skills and expertise beyond Skilled Level.
3. Demonstrate, through duration of years in field and continued education, a desire to develop specific high-level skills.

Supervisory-Level personnel are persons who no longer should be required to do the mechanics of the jobs. Instead, they should be capable of directing others from aforementioned levels to perform the job tasks. This position is approximately 50 per cent paper work and 50 per cent work-relation directionals. Anyone wishing to advance to Management Levels should be capable of achieving the following:

1. Demonstrate the ability to manage time and materials.
2. Demonstrate the ability to organize and control workflow of self and others.
3. Demonstrate the ability to communicate efficiently and effectively.
4. Demonstrate the ability to compensate for varying levels of stress on oneself.
5. Willingness to acquire position over others.

Management Level positions vary considerably. Advancement in Management Level positions is normally done through retirement or demise of Upper-Level Management persons. Years of expertise and sheer endurance may or may not cause an upper-level move. At this level, monitary compensations normally don't vary excessively from position to position. It has been determined that advancement is more politically-motivated in Management Level structure.

1. Demonstrate ability to integrate with upper-management personnel and make definite political contact as far as direction of management.
2. Demonstrate ability to sacrifice the use of scapegoat and take full responsibility for major decisions.
3. Demonstrate ability to manage.(If going into ownership, financial and business capability should be severely scrutinized before any decisions are made.)

SOLAR INSTALLER CAREER LEVELS

OWNER, CONTRACTOR, MANAGEMENT

6 FOREPERSON, LEAD PERSON, SUPERVISOR

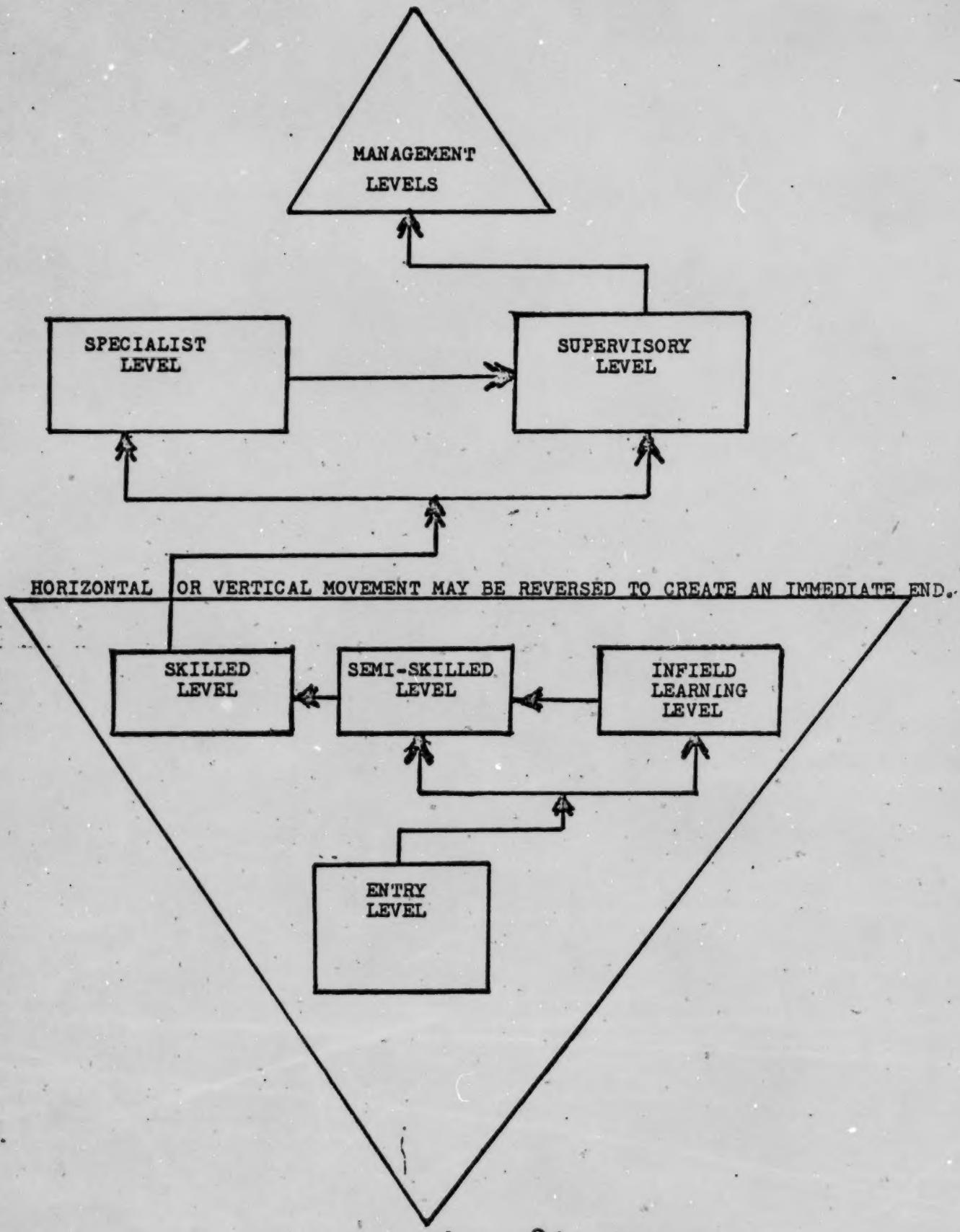
5 TECHNICAL SERVICE PERSON, ON SITE SALES, SPECIALIST

4 JOURNEY PERSON, GRADUATE STUDENT, SKILL AND EXPERIENCE

3 ADVANCED APPRENTICE, 2 YEAR DEGREE, SEMI SKILLED

2 COMPONENT PERSON, DEGREE SEEKING, APPRENTICE, IN-FIELD LEARNING

1 BEGINNING STUDENT-HELPER-LABORER ENTRY


MANAGEMENT
LEVELS
SPECIALIST
LEVEL
SUPERVISORY
LEVEL
HORIZONTAL OR VERTICAL MOVEMENT MAY BE REVERSED TO CREATE AN IMMEDIATE END.
SKILLED
LEVEL
SEMI-SKILLED
LEVEL
INFIELD
LEARNING
LEVEL
ENTRY
LEVEL

B. COMPETENCIES

See Final Report

C. NEED FOR GUIDES

The need for curriculum guides for training of solar installers was made apparent when College of DuPage's HVAC Program Coordinator started to research the availability of existing course guides.

Since the time that a need was determined, June 1978, several manufacturers of solar products have come out with their own guides and many schools have developed programs--as indicated in Illinois Solar Energy Directory, page 83: Solar Energy Education Programs in Illinois. However, on page 92, Energy Education Materials, under Curriculum Aids, there is no listing of a guide for solar installers.

The manufacturers' manuals are slanted toward their own product--deservedly so--and the other institutional programs are mostly oriented toward consumers and design engineers.

These findings made it apparent that a Solar Installer's Guide which consolidated all installation procedures in a step-by-step manual was needed.

The curriculum guides that follow were developed to be used in training persons who have a desire to be servicepersons in the comfort industry. The title may be of a misleading nature, if it is assumed that all that will be taught through these guides is solar. Due to the sunbelt that Illinois falls into, it is necessary for us to use backup systems along with solar. At this point in time most solar design applications are at 60% solar and 40% backup heat. For this reason having knowledge about the backup systems is a necessity. Also to make one's self employable and a viable serviceperson, it is necessary to be well versed in all realms of the heating, cooling, refrigeration, ventilating, solar industry.

For persons such as carpenters, plumbers, salespersons, and technicians it may be very beneficial to combine use of Solar Energy Installers Curriculum Guides with Illinois Solar Energy Systems Installation Training Program. These two curriculum guides used in conjunction with each other will cover all areas of the solar industry.

The Solar Energy Installers Curriculum Guides were developed from careful analysis of job tasks required of the Heating, Ventilating, Air Conditioning, Solar-Serviceperson. Competencies were developed and approved through an advisory board made up of individuals from industry. NOTE: These competencies are listed in the final report submitted with this guide.

I. HOW TO USE THE SOLAR ENERGY INSTALLERS CURRICULUM GUIDES

A. Determine Students Needs

The curriculum guides have been broken down into areas. First determine area of study desired. The guides are further subtitled under unit numbers. Once you have determined the area of study the instructor can then determine from student's competencies what areas the person is needing instruction. This is done by reading unit titles if the person is still not clear as to whether further instruction in this area is necessary. Guides are listed with instructional objectives and outlines of materials to be covered. Through use of competency statements and the breakdown of each unit a decision can be made and the instructor should be capable of developing a program of units that the student must take to be proficient at the job task level and extent desired by student. Student evaluation parameters listed under each unit should match with competencies desired.

B. Teaching of the different units can progress by use of the unit's guidelines.

1. Instructional objectives are laid out.
2. Reference materials are listed for each unit and chapters, sections, pages, etc., are noted.
3. Visual aids are indicated along with any materials available to instructors.
4. Method performance conditions required of the instructors are listed.

5. An outline showing a step-by-step breakdown of all subject matter to be covered is listed.
6. Student evaluation parameters to meet competencies are listed.
7. Sequence of instruction is listed for all units.
   NOTE: This sequence may be varied in its order, but all steps should be covered.

   Unit tests are provided with all units where necessary-further testing may be desired.

C. It should be noted that the curriculum provided is to be used as a guide to develop the specific training requirements of the student in question. The never ending advances in the comfort industry may make it necessary to modify units wihin this guide.

INSTRUCTIONAL RESOURCES

Slide Set	Kai Dib Films International Richard L. Crowther, AIA, Solar Group Architects Sun Earth: Solar Architecture
Text & Slides (also available)	Solar Energy and Heating Systems P.O. Box 261 Glendale, California (1977)
Slide Set and Trainers	Lennox Industrial Inc. - Lennox Phase I (SA) Solar Application Lennox Educational Products (Iowa-Texas) 1600 E. Linn Marshalltown, Iowa 50158 (1978)
(Other educational trainers)	RT-5, EB-5, ST-17, AP-3
Trainer System (total)	Suncell Solar Heating System Research Products Corporation Madison, Wisconsin 53701 (1977)
Texts	Sun Earth: How to Apply Free Energy Sources to Our Homes and Buildings Crowther/Solar Group 310 Steele Street Denver, Colorado 80206 (1977)
	Student Guide Sheet Metal Shop Practice American Technical Society (1976) Chicago, Illinois 60637
	Sheet Metal Technology Richard S. Budzik The Bobbs Merrill Company, Inc. (1979) Indianapolis, Indiana 46268
	Sheet Metal Shop Practice Leo A. Meyer American Technical Society (1975) Chicago, Illinois 60637
	Air Conditioning Metal Layout Joseph J. Kaberlein Benziger Bruce & Glencoe, Inc. (1973) Beverly Hills, California 90211
	Practical Layout for the Sheet Metal Shop Zinngrabe and Schumacher Delmar Publishers (1975) Albany, New York]2205

Texts (con't)

The Solar Decision Book: A Guide for Heating Your Home with Solar Energy, by Richard H. Montgomery (John Wiley & Sons, New York. 1978)

Fundamentals of Solar Heating (Correspondence Course)
U. S. Department of Energy
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161 (1978)

Heating and Air Conditioning Systems Installation Standards for One and Two-Family Dwellings and Multi-Family Housing, Including Solar, by Better Heating and Cooling Bureau (1977) SMACNA

Illinois Solar Energy Directory- Illinois' Alternative Energy Program.
Green and Pogany
325 West Adams Street, Room 300
Springfield, Illinois 62706 (1978)

National Solar Energy Education Directory
Solar Energy Research Institute
1536 Cole Blvd.
Golden, Colorado 80401 (1979)

Solar Energy Systems - Liquid, Air, Storage Systems
Solaron Corporation
440 Gallerig Tower (Application Engineering Manuals,
720 S. Colorado Blvd. Installation Manuals, Owners Manuals,
Denver Colorado 80222 and Design Manuals.)

Job-Related Training - Solar
Lennox Air Conditioning and Heating Inc.
Lennox Education Products
1600 E. Linn,
Marshalltown, Iowa 50158 (1978)

Model Document for Code Officials on Solar Heating and Cooling of Buildings (1979)
U. S. Depart of Energy
Cont. #EM-78-C-01-4281

Solar Energy - Progress and Promises
Council on Environmental Quality (1978)
Superintendent of Documents
Washington D. C. 20402
Stock #041-011-0036-0

Solar Energy in America's Future
Division of Solar Energy
Energy Research and Development Administration
Washington, D. C. (1977)
Stock #060-000-00078-6

Texts (con't)

Solar Energy Information and Data for Illinois, by Changnohs
Illinois State Water Survey (1978)
Cir. No.133 - (12-78-1500)

Solar Energy Handbook - Theory and Application
Power Systems Group AMETEK Inc.
Chilton Book Company/Radnor, Pennsylvania (1979)
Library of Congress Card No. 78-14646

Proceedings of Solar Energy Storage Options, Vols 1 & 2
March, 1979, San Antonia, Texas
National Technical Information Service
U. S. Department of Commerce
Springfield, Virginia 22161
Cont. 790328-P1
Final Report H-C0199-79-753F (1979)

Suncell Solar Heating Systems
Research Products Corporation (Solar Division)
Madison, Wisconsin
and
Solar Energy in Industrial Process Heating
Installation Manuals, DHW & Total House

Installation Guidelines for Solar DHW Systems in One and Two-Family Dwellings, by Franklin Research Center
Philadelphia, Pennsylvania
Superintendent of Documents
U. S. Government Printing Office
Washington, D. C. 20402
Contract #H-2377

Revere Sun-Pride System
Revere Solar and Architectural Products, Inc.
Rome New York 13440
Installation Manual - DHW & Total House

Design Manual for Solar Heating of Buildings and Domestic Hot Water, by Field.
Sol Pub Co.
P. O. Box 9209
College Station, Texas 77840 (1977)
Publication 501

Design Criteria for Solar Heated Buildings
Sunworks Technical Publication (1975)
Sunworks, Inc., Guilford, CT 06437

Energy and Solar Heating, by Bason
An Issue-Oriented Module Coordinated by AA of PT (1977)
Michigan State University

Texts (con't)

DOE Facilities Solar Design Handbook (1978)
U.S. Dept. of Energy DOE/AD-006/1
National Technical Information Service
U.S. Dept. of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Stock #061-000-00097-6

Solar Energy in Buildings - For Engineering, Architecture and Construction
John Wiley & Sons, New York (1979)

Here Comes the Sun - A Manual Explaining Practical Solar Heat Applications with Blueprints for Solar Systems Using Air and Water, by Xoxon
Jordan College, Michigan (1977)

Energy Saving Conservationist Solar Systems
A. O. Smith Corp.
Consumer Products Division - Solar Catalog (1978)
Kankakee, IL
7250 S. Cicero Avenue
Chicago, IL 60629

Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings (1976)
Energy Reseafch and Development Administration
Division of Solar Energy
Washington, D. C. 20543
NBSIR 76-1187

SEM - 79
Solar Engineering Master Catalog - Solar Industry Index
Solar Energy Industries Association
Solar Engineering Publishers Inc.
8435 N. Stemmons Freeway
Dallas, Texas 75247

Basic Sheet Metal Skills
Philip M. Johnston and Murray Liebowitz
Delmar Publishers (1977)
Albany, New York 12205

Sheet Metal Layout
Leo A. Meyer
Gregg Division/McGraw Hill Book Company (1979)
New York, New York

Precision Sheet Metal Shop Theory
Richard S. Budzik
Howard W. Sams & Company, Inc. (1969)
Indianapolis, Kansas City, New York

Texts (con't)

Duct Design for Residential Winter & Summer Air Conditioning & Equipment Selection
Air Conditioning Contractors of America
Air Conditioning Contractors of America (1979)
Washington, D.C. 20036

Load Calculation for Residential Winter & Summer Air Conditioning
Air Conditioning Contractors of America
Air Conditioning Contractors of America (1975)
Washington, D.C. 20036

Equipment Selection & System Design Procedures
National Environmental Systems Contractors Association
National Environmental Systems Contractors Association (1973)
Arlington, Virginia 22209

Comfort Heating
Billy C. Langley
Reston Publishing Company, Inc.(1978)
Reston, Virginia 22090

Domestic & Commercial Oil Burners
Charles H. Burkhardt
McGraw Hill Book Company (1969)
New York, New York

Fundamentals of Gas Combustion
American Gas Association Laboratories
American Gas Association (1973)
Arlington, Virginia 22209

Trane Reciprocating Refrigeration
The Trane Company
The Trane Company (1977)
LaCrosse, Wisconsin

Industrial Refrigeration Course I
Elliott R. Hallowell, Guy R. King, & Ivan C. Stepnich
Refrigerating Engineer & Technicians Association & National Association of Refrigerated Warehouses (1972)
Chicago, Illinois 60611
Washington, D.C. 20014

Industrial Refrigeration Course II - Systems
Refrigerating Engineers & Technicians Association
Refrigerating Engineers & Technicians Association (1975)
Chicago, Illinois 60611

Texts (con't)

Refrigeration and Air Conditioning
Billy C. Langley
Reston Publishing Company, Inc. (1978)
Reston, Virginia

Environment Control Air Conditioning and Refrigeration Theory and Application
Michael K. Weaver, James M. Kirkpatrick
Harper & Row Publishers (1974)
New York, San Francisco, London

Modern Refrigeration and Air Conditioning
Andrew A. Althouse, Carl H. Turnquist, Alfred F. Bracciano
The Goodheart-Willcox Company, Inc. (1975)
South Holland, Illinois

Refrigerants and Service Pointers Manual
E. I. DuPont DeNemours & Company
E. I. DuPont DeNemours & Company (1970)
Wilmington, Deleware 19898

Refrigeration and Air Conditioning
Air Conditioning and Refrigeration Institute
Prentice Hall, Inc. (1979)
Englewood Cliffs, New Jersey 07632

Basic Air Conditioning
Guy R. King
Nickerson & Collins Company (1965)
Chicago, Illinois 60644

Principles of Refrigeration
Roy J. Dossat
John Wiley and Sons (1978)
New York, Santa Barbara

Trane Air Conditioning Manual
The Trane Company
The Trane Company (1977)
LaCrosse, Wisconsin

Control Systems for Heating, Ventilating & Air Conditioning
Roger W. Haines
Delmar Publishers (1978)
Albany, New York 12205

Understanding Solid-State Electronics
Texas Instruments Learning Center
Texas Instruments Learning Center (1977)
Fort Worth, Texas 76107

Texts (con't)

Job Related Training-Lennox Air Conditioning & Heating
Lennox Industries (1977)
1600 E. Linn
Marshalltown, Iowa 50158
Phase 1(S), 11(S), 111(S)

Honeywell Residential Controls Training
Honeywell (1971)
2701 4th Avenue S.
Minneapolis, Minnesota 55408
Gas Controls, Oil Controls, Air Conditioning Controls, Cooling Controls, Controllers

Electric Circuit Fundamentals
Prentice Hall, Inc. (1979)
Englewood Cliffs, New Jersey 07632

Handbook of Simplified Electrical Wiring-Lenk
Prentice Hall, Inc. (1975)
Englewood Cliffs, New Jersey 07632

Basic Electricity-Honeywell Residential Training Manual
Minneapolis-Honeywell Regulator Company (1958)
Minneapolis, Minnesota

Electric Modulating Controls Service Handbook
RA 890 Service Handbook
Honeywell Tradeline Controls

Fundamentals of Pneumatic Controls
Robert Shaw Uni-Line Division (1976)
P.O. Box 2000
4190 Temescal Street
Corona, California 91720

Workbench Guide to Electronic Troubleshooting-Genn
Parker Publishing Company, Inc.(1977)
West Nyack, New York

Control Theory and Fundamentsl Study Course 1 & 2
RETA
435 North Michigan Avenue
Chicago, Illinois 60611

Electric Controls for Refrigeration and Air Conditioning
Langley
Prentice Hall, Inc. (1974)
Englewood Cliffs, New Jersey 07632

Texts (con't)

Copper Brass Bronze Product Handbook
Copper Tube
Copper Development Association, Inc.
405 Lexington Avenue
New York, New York 10017

Carrier GTR & GTE Service Training Aids
Carrier Air Conditioning Company
Syracuse, New York

Magazines and Newspapers

Solar Products Specifications Guide
Solar Age Magazine
P. O. Box 4934
Manchester, New Hampshire 03108

Solar Age
P. O. Box 4934
Manchester, New Hampshire 03108

SERI - Solar Energy Research Institute
1617 Cole Blvd.
Golden, Colorado 80401

AREA - SOLAR APPLICATION INSTALLATION

Unit 1 - Solar System History

I. Instructional Objective

The student will realize that man has been trying to harness the sun's energy and put that energy to work for many centuries. It is this scientific approach in the past that in part, at least, accounts for our present solar systems that have been operational for several decades. It is important for the student to understand the purpose of these systems and the fact that present energy situations have brought solar systems to the attention of all. It is project ingenuity like these that provide the scope of future achievements in solar development.

II. Reference Material

Lennox Solar (Volume I) Solar Systems Past and Present 1-57
Solaron - Solar Energy Systems Section 100
Sun Earth Chapter 7
Solar Decision Book Section 5 and 6
Solar Energy Progress and Promise pages 1-43
Solar Energy in America's Future pages 15-43

III. Visual Aids

Lennox Slide Presentation 1 (SA) 1SASS-781-L5 - Slide 1-9
Kaibib Film, International Sun Earth (H35-H46)

IV. Method - Performance Conditions

The slides authentically illustrate past experiments for utilizing solar energy. They are to be used to explain the idea and operation of these early devices. The project information (see reference materials) and slides provide references to establish the concepts of residential solar space heating and domestic hot water systems. The students are encouraged to discuss these systems as time allows. Sun Earth slides will give a total overview of historic use of natural energies.

V. Outline

1. Purpose
   A. Energy conservation

2. Early solar technology
   A. Solar stove
   B. Printing press
   C. Water purification

3. Demonstration projects
   A. Discussion

4. Solar past and present
   A. Past
      (1) Babylon 2100 B.C.
      (2) Hopi Indians
      (3) Archimedes 212 B.C.
          a. solar reflectors
      (4) France 1600 A.D.
          a. solar engine
      (5) France 18th century
          a. solar furnace
      (6) United States 1800's
          a. solar hot air engines
      (7) Pifre's solar press
      (8) Tellier flat plate collector - 1885
      (9) Solar food preparation - 1916
   B. Present - early 1970's
      (1) 1930-1970 - 50 solar homes total
      (2) September 1975 HVD
          a. go over 55 different HUD demonstrations

VI. Student Evaluation Parameters

Student will identify the four main solar alternate energies - passive and active solar systems - wind - wave - biomass. Application of any one of these systems in past or present day situation mock ups will be demonstrated on paper.

VII. Sequence of Instruction

1. Read assigned reference materials.
2. View assigned slide presentations.
3. Discuss in class the effects of alternate energies through history that have advanced up to today's technology.
4. Take unit test (paper written on mock up use of one of any four of our solar energies).

AREA - SOLAR APPLICATION INSTALLATION

Unit 2 - Introduction to Active Solar

I. Instructional Objective

Introduction to Solar Heating and Cooling explains the basic concepts, structure, and economic considerations involved with solar heating and cooling. The lesson is designed to be a comprehensive introduction which will permit an overall understanding, together with some insight, to the economic implications involved with these systems.

The student will be exposed to a portion of the private and governmental emphasis that is currently directed toward solar systems as a developing technology. Obviously, these solar projects provide a prime opportunity to become aware of the complexities encountered when attempting to collect and store the sun's energy. The student will understand the need for accountable solar standards and codes wherever solar applications are completed.

The legal responsibilities for those who design, engineer, install, and use solar assisted heating systems are two-fold. There is responsibility for (1) the heath and safety of people who may be in contact with the system, and (2) the protection of the property in order to construct and maintain an efficient and effective heating system.

People must be informed about possible toxic or allergic reactions that result from contact with materials used in the system. There is also the possibility of electrical shock or burns.

Property must be protected by enforcing building codes and licensing practices for installers and servicing personnel. There are also problems related to real estate that deal with appraisal practices, incentives to invest in solar heating, insurance, and warranties of components in the system.

II. Reference Material

Fundamentals of Solar Heating (Lesson I & II)
Solaron - Solar Energy Systems Section 300
Lennox Solar (Volume I) Solar Systems Present
Solar Decision Book Section 7
Model Documents for Code Officials on Solar Heating and Cooling of Buildings Section B
Solar Energy Handbook Chapter 1

III. Visual Aids

35 MM Slides Lennox

IV. Method - Performance Conditions

The 35 MM slides are used to generate a discussion concerning the purpose of solar systems and the approaches that have led to that goal. The general discussion will be guided to cover key points such as the state of the technology, architectural compatability, and the difficulties associated with working with a variable heat source. Each student will be given the opportunity to talk about his solar experiences.

V. Outline

I. State of the technology
   - A. Heating
     - (1) space
     - (2) hot water preheat
     - (3) swimming pools
   - B. Cooling
     - (1) absorption
     - (2) mobile solar system
   - C. Solar - heat pump

2. Role of ERDA, HUD and like agencies
   - A. Financial assistance

3. Collector installations
   - A. Methods
     - (1) roof
       - a. structural considerations
     - (2) ground level
   - B. Architecturally pleasing
   - C. Three dimensional zoning
   - D. Variable heating values

4. Storage
   - A. Methods
     - (1) water
     - (2) rock

5. Building codes
   - A. FHA guidelines

6. Systems
   - A. Marv Anderson
   - B. French solar system
   - C. Ocean system

7. Student participation
   - A. Seminar attendance
   - B. Local installations

8. Economic analysis/Life cycle costing
   - A. Factors affecting economics
   - B. Commerical/Industrial application
   - C. Life-cycle cost analysis - sample calculation
   - D. Computer life-cycle cost analysis worksheet

VI. Student Evaluation Parameters

1. The student will do sample life cycle costing analysis.
2. The student will discuss local and federal agencies involved with solar.
3. Name the major components of a solar heating and solar cooling system.
4. Distinguish the differences between air and liquid systems.
5. Identify the differences within the component groups.
6. Describe what types of systems have practical value as opposed to systems under development with possible future promise.
7. Explain the difference between active and passive solar heating.
8. Describe the basic expectations of performance of different types of systems.
9. Recognize the advantages and disadvantages of the various types of components within a system.
10. Identify and describe the economic implications of solar heating and solar cooling.
11. List all the items involved in costing a system.
12. Name the climatological characteristics which are involved in sizing a solar heating/solar cooling system.
13. Explain how the availability and cost of conventional fuels will impact on solar heating/solar cooling.
14. Describe the hazards of a solar heating system to people and property.
15. Identify and explain the problems relating to right to light and freedom from glare.
16. Discuss building codes and zoning requirements.
17. Identify minimum quality standards and installation requirements for solar systems.
18. Describe problems related to property appraisals.
19. Analyze problems related to incentives to invest in a solar system.
20. Identify problems relating to insurance and solar systems.
21. Describe problems relating to warranties and solar systems.

VII. Sequence of Instruction

1. Read assigned material.
2. Quiz on building codes.
3. View slides.
4. Take Unit 2 quiz.

Unit 2 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. A solar heating and/or cooling system is any system which utilizes solar energy as source of heat.

T F 2. A passive system usually has no moving parts and is not the major concern of the people taking this course.

T F 3. A concentrating solar collector best utilizes diffuse solar radiation.

T F 4. The insulation beneath the absorber plate helps produce a quieter operating solar collector.

T F 5. Like flat plate collectors, concentrating collectors can operate in any weather conditions so long as minimal light conditions exist.

T F 6. An R-10 insulation rating is more than adequate for the surfaces of liquid thermal storage units.

T F 7. Packing and/or side wall stress is not a problem in a pebble-bed heat storage solar system.

T F 8. Insulation material on the bottom of a 6' water storage tank must withstand a compression weight of 280 pounds per square foot.

T F 9. A good quality steel tank will not be subject to any problems during the life of the system.

T F 10. While a solar air system requires lower capital costs, more electric energy is required during its life to move the heat from the collector to storage to use as compared to a liquid solar system.

T F 11. Liquid solar systems have a long history of working well and the critical cost is low.

T F 12. A heat pump could be considered as an auxilliary heat supply in some areas of the country.

T F 13. Of the absorption refrigeration currently in use, the Lithium-Bromide chillers appear to hold the most promise.

T F 14. Through the use of a Solar Rankine-Cycle Engine, a device such as a heat pump could become a solar related device even in its cooling cycle.

T F 15. The cost of conventional energy (gas, oil, etc.) should level off within the next five years.

T F 16. The amount of solar radiation available during the heating season is a major economic consideration for a solar heating system.

T F 17. Currently, electricity is the best fuel to buy in terms of cost per million BTU's throughout the country.

T F 18. Property taxation rate and loan interest rate are just two of the items which must be considered when costing a solar heating system.

T F 19. Except for minor differences, cities along the same latitude have equal solar BTU's available to them.

T F 20. Snow is not as much of a consideration when planning a solar energy system for Flagstaff, Arizona as for Boston, Massachusetts.

Fill in the blanks with the word (or words) which most accurately completes the thought.

21. The two basic types of solar energy systems are called active and _____.

22. A roof monitor, a south-facing window, and a _____ are all examples of passive solar collectors.

23. The two basic types of solar collectors are _____ or _____.

24. The absorber plate is usually _____ in color which aids in _____ the solar radiation.

25. Solar collectors tend to lose heat through _____, _____ and/or _____.

26. The layer of still air between the glass and the absorber acts to reduce _____ loss.

27. Because of their size, air thermal storage units are normally placed into the building _____ constructing.

28. Round pebbles _____ to _____ in size are ideal for a pebble-bed heat storage unit.

29. If a horizontal pebble-bed heat storage unit is used, the height of the unit must not exceed _____.

30. Water heat storage units are subject to_____, especially at the _____ _____.

31. Two types of auxilliary electric heat in solar heating systems are _____or_____or both.

32. For cooling residential building, solar energy is only directly useful in_____methods.

33. In terms of realistic economics, only the _____ system appears to be practical for solar cooling, at least into the early 1980's.

34. A heat pump is a mechanical vapor-compression system consisting of a _____, _____, _____ _____ and an_____.

35. A prototype solar heating system, using circulating air, has been operational since 1957 with _____major problems and essentially no _____costs.

36. Solar heating should provide_____percent of the annual heating requirements to be practical and economical.

37. Considerations that may influence users toward solar heating are:
    1. Incorporation of systems into_____ _____.
    2. First costs verses _____ _____ _____
    3. Ease of _____and_____
    4. _____and reliability.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

38. Which item is NOT a component of an all-air solar heating/solar cooling system?
    a. auxiliary furnace
    b. heating/cooling distribution system
    c. solar collector
    d. boiler
    e. cooling unit
    f. thermal storage unit

39. Of the cooling systems listed below, indicate which is currently available for residential solar cooling.
    a. evaporative cooling through rock bed
    b. Munter's environmental control
    c. Thiethylene glycol open cycle diseccant system
    d. radiative cooling

40. Based on the factors presented in this unit, it is essential that solar heating/solar cooling systems provide the user with:
    a. comfort and safety
    b. maximum return for dollar invested
    c. a good looking exterior to the building
    d. snob appeal

T F 41. There is attention given to the health and safety of people related to solar heating utilization.

T F 42. A solar home owner can do nothing if a neighbor's tree grows and shades the collector.

T F 43. It is extremely difficult to find consistent building codes for solar heated buildings.

T F 44. The Uniform Solar Energy Code has been found unacceptable for solar heating standards and guidelines.

T F 45. Cross connection refers to hooking potable water with sewer connections.

T F 46. Due to the lack of local codes, inspectors show little concern for solar heating equipment.

T F 47. Changing components may be simpler than changing codes if controversy arises.

T F 48. Because of the urgency to experiment with solar heating, there aren't any jurisdictional labor problems.

T F 49. A solar heating system may be considered a liability by some appraisal practices.

T F 50. Insurance companies are very reluctant to underwrite solar heated buildings.

T F 51. The Federal Trade Commission is the agency that regulates warranties.

T F 52. A full warranty may only relate to a part of a product.

T F 53. A full warranty states that there cannot be a time limit to the duration of the guarantee.

T F 54. Pro-rating is generally associated with limited warranties.

T F 55. A limited warranty protects only the original purchaser.

T F 56. Implied warranties are explicit in identifying the function of a product.

T F 57. Warranties are to be prominently displayed on the product or packaging.

58. Several aspects of health and safety in owning solar heating equipment relate to _____ and _____problems.

59. Problems of "Right to Light" arises from _____and _____shading.

60. If a collector creates glare, the property owner may be required to _____ _____ _____.

61. Proper placement and purpose for building on a lot in a given location is related to_____.

62. Incentives to install a solar system may be encouraged by legislation could be considered _____or_____

63. Compensatory regulations would deal with _____and_____ such as _____, _____ and _____

64. Warranties are classified as either _____, _____, or _____

65. Problems with building codes relate to the:

a._____

b._____

c._____

d._____

66. When dealing with solar heating systems, an appraiser may choose to:

a._____

b._____

c._____

67. Regulatory legislation includes:

a. _____

b. _____

c. _____

d. _____

68. A full warranty must include:
a. repairs at no cost and done in reasonable time
b. cover only original purchase
c. if not repairable replace or refund money
d. all of the above

69. Which of the following considerations must be dealt with when determining placement of solar collectors.
a. freedom from glare
b. right to light
c. building codes
d. all of the above
e. none of the above

AREA - SOLAR APPLICATION INSTALLATION

Unit 3 - The Sun

I. Instructional Objective

Solar Radiation explains what this course is all about - the use of the solar energy which reaches earth for heating and cooling. In this lesson, you will discover the way energy given off by the sun is altered before it reaches the earth, and how the energy that does reach the earth can best be utilized. Thus, your objective will be to recognize the factors which affect the availability of solar radiation at the earth's surface.

The student will become knowledgeable of the energy intensity ranges of light radiation. Variables, such as latitude, reflection, diffusion, altitude, climatic season, and air mass number will allow the student to account for energy losses and explain the heat energy available for collection at the earth's surface. This will provide an insight as to the best orientation possible for a collector type. Weather and radiation data tables are a convenient means to tabulate the effects of all variables. The student will be able to read and extract needed data from typical reporting stations. The student will be exposed to data gathering instrumentation and will be expanding his technical vocabulary to accommodate the mechanics of this variable heat source.

II. Reference Material

Lennox Solar (Vol. 1) Sun 1-13
Solar Energy Handbook (Chapter 2 & 3)
Solar Decision Book (Chapter 5)
Fundamentals of Solar Heating (Lesson 2)
Solaron Solar Energy Systems Section 400 (1-5)
Energy and Solar Heating (Solar Radiation 16-29)
Solar Energy in Formation and Data for Illinois
Suncell Installation Manual (Page 2)

III. Visual Aids

Lennox Slides (10-26)
Sun Earth Slides 69-123

IV. Method - Performance Conditions

The instructor should ask a series of probing questions concerning observed seasonal positions of the sun and atmospheric conditions that would affect collection of solar energy. During this class discussion the slides are used to reinforce, intensify and stimulate interest and information in the various subject areas. Students are called upon to interpret information in weather data tables and the radiations charts. This may be in front of the class so the student has the opportunity to control discussions. Test instruments are passed around the class and students are encouraged to keep their discussion in terms of the technology.

V. Outline

I. Solar mechanics
- A. Earth - Sun plane
  - (1) earth's axial tilt - 23-½°
  - (2) sun tracting
    - a. Tropic of Cancer
    - b. Tropic of Capricorn
- B. Seasonal changes
  - (1) altitude of sun
    - a. summer - winter solstice
    - b. vernal - autumnal equinox
    - c. BTU per area on horizontal differences
  - (2) horizon
  - (3) azimuth angle
  - (4) zenith

2. Solar radiation
- A. In space
  - (1) beam radiation
    - a. spectral analysis
  - (2) solar constant (428 BTUH/FT^2) = S_c
- B. At earth's surface
  - (1) types
    - a. beam
    - b. diffused
    - c. reflected
  - (2) altitude above sea level
  - (3) latitude
  - (4) air mass number
  - (5) radiation belts
  - (6) radiation charts
    - a. graph explanation
  - (7) intercepting solar radiation
    - a. solar noon
    - b. tilt angle for collector
    - c. azimuth angle
    - d. altitude of sun angle
  - (8) climatic conditions
    - a. cloud cover
- C. Solar weather and radiation data tables
  - (1) reporting stations
    - a. data taken between 11 A.M. and 1 P.M.
  - (2) latitude
  - (3) horizontal radiation
  - (4) fraction of maximum
    - a. cloud cover influences
    - b. relate to S_c
  - (5) degree days (D-D)
    - a. definition - 65° base
    - b. example
    - c. heating requirement notation used by gas companies
  - (6) tilted surface variations
- D. Instrumentation
  - (1) pyronometer
  - (2) temperature

E. Vocabulary
   (1) degree day
   (2) azimuth
   (3) altitude
   (4) beam radiation
   (5) tilt angle (slope)
   (6) solar noon
   (7) air mass number
   (8) diffused
   (9) reflection
   (10) insulation
   (11) solar constant
   (13) zenith
   (14) shortwave radiation

3. Solar energy in space
   A. Radiation reaching outer atmosphere
      (1) types of radiation
      (2) altitude and its affect on radiation
      (3) average daily radiation
      (4) solar radiation belts
      (5) radiation charts
   B. Weather data instruments
      (1) pyronometer
      (2) wind speed and direction
      (3) temperatures ambient
   C. Intercepting solar radiation
      (1) collector tilt angle
      (2) azimuth angle

VI. Student Evaluation Parameters

1. Recognize those conditions - for example, clouds, dust and other atmospheric pollutants; shading from trees and buildings; and collector orientation and tilt - which affect solar energy reaching the collector.

2. Describe the difference between direct and diffuse radiation.

3. Recognize the various units of measure used to report solar radiation.

4. Convert solar radiation fron one unit of measure to another using standard coversion factors.

5. Determine the amount of solar radiation available for a given period of time.

6. Describe the effect of seasonal variations.

7. Recognize the importance of hourly variations.

8. Learn and locate sources of solar data.

9. Select the data needed for planning a solar system.

10. Blend the information learned in Unit 1, 2 and 3 into a singular unit of knowledge.

VII. Sequence of Instruction

1. Read assigned reference material.

2. View slides.

3. Work sample problems in Sun's Angle in Respect to Alignment of Panels.

4. Take Unit 3 Quiz.

5. Take Unit 1, 2 and 3 examination.

6. Energy and Solar Heaing, do exercises 13-19, lab exercise page 23.

Unit 3 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. The sun's energy can be converted from electromagnetic waves to heat.

T F 2. The sun is approximately 93 million miles from earth.

T F 3. The earth's inhabitants are not all that interested in solar energy.

T F 4. Infrared radiation waves are long.

T F 5. The sun produces the greatest amount of energy in the visible range.

T F 6. A solar collector absorbs radiation from two of the three radiation regions of interest to this course.

T F 7. The upper atmosphere, clouds and dust all contribute to scattering solar radiation.

T F 8. Solar energy on a horizontal surface will show month to month variations.

T F 9. Solar rays must pass through a larger thickness of atmosphere in the early morning.

T F 10. The exposure of solar energy on vertical surfaces is the same as the exposure on horizontal surfaces.

T F 11. Of greatest use is knowing the expected monthly radiation on a surface during the period of the heating season.

Fill in the blanks with the word (or words) which most accurately completes the thought.

12. It is to the sunlight that was received in past ages that we owe the existence of our _____ fuels.

13. The three types of solar rays which are of interest to this course are _____, _____ and _____

14. The abbreviation of British Thermal Units per square foot is _____.

15. To convert Langleys into BTU/ft^2, multiply by _____

16. UV is the abbreviation for _____

17. Infrared is abbreviated_____

18. Materials with a temperature below 800°F emit only_____ radiation.

19. In the winter, the sun is_____in the sky than in the summer, and the resultant angle_____the amount of radiation intercepted on a flat surface.

20. The amount of energy intercepted by a horizontal surface is much _____as the angle (height) of the sun increases.

21. Generally speaking, the angle of the sun above the horizon at noon is about_____in the winter and _____in the summer for latitudes near 40°N.

22. The greatest intensity of solar radiation occurs during the_____ hours.

23. North wall exposure to direct solar radiation is not important to people living in the_____hemisphere.

24. In the northern hemisphere, the solar collector is aimed_____

25. As a general rule, a solar collector used for heating only should have a tilt equal to the _____plus_____degrees.

26. A solar collector can be oriented _____east or west of due south without any serious effect on its collecting ability.

27. A solar collector oriented 15 degrees to the east of due south will _____the time of peak collection by_____hour.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

28. The earth offers the sun what quality of target to absorb its radiation?
    a. very good
    b. average
    c. very small
    d. none of the above

29. If the amount of solar radiation received by the earth were reduced,
    a. nothing would happen
    b. the earth would freeze
    c. the earth would boil

30. The surface temperature of the sun is approximately
    a. 5,000°F.
    b. 10,000°F.
    c. 15,000°F.
    d. 20,000°F.

31. Langley/min is the abbreviation for
    a. calories per square centimeter
    b. the 47 second minute named after Carl Langley
    c. calories per square centimeter per minute
    d. both A and C

32. The solar constant is equal to
    a. 1.940 Langley's/min.
    b. 428.7 BTU/(ft.^{2} h)
    c. both A and B
    d. none of the above

33. When someone says than an air conditioner is rated at one ton, they mean
    a. the unit will produce the same BTU's of cooling as melting one ton of ice in one day
    b. the air conditioner weighs one ton
    c. the unit will cool one ton of anything for a day

34. To tilt the solar collector so that it is perpendicular to the sun's rays is
    a. advantageous
    b. expensive
    c. a waste of time
    d. all of the above

Unit 1, 2 and 3 Examination

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. The two basic types of solar energy systems are called active and passive.

T F 2. The two basic types of solar collectors heat metal or liquid.

T F 3. The absorber plate is usually silver in color which aids in reflecting the difuse solar radiation.

T F 4. Solar collectors tend to lose heat through leaks, a high R factor, and convection.

T F 5. Because of their size, air thermal storage units are normally placed into the building after construction.

T F 6. For cooling residential buildings, solar energy is only directly useful in cooling methods using refrigeration cycles.

T F 7. A prototype solar heating system, using circulating air, has been operated since 1937 with no major problems and essentially no maintenance costs.

T F 8. Solar heating should provide 50-80 percent of the annual heating requirements to the practical and economical.

T F 9. It is to the sunlight (solar energy) that was received in the past ages that we owe the existence of our atomic fuels.

T F 10. To convert Langleys into BTU/ft^2, multiply by 221.

T F 11. Materials with a temperature below $800^{o}F$ emit only infrared radiation.

T F 12. Radiation is termed direct radiation if it has not been scattered by clouds and dust and diffuse if it has.

T F 13. The sun's position in our sky varies because, as the earth follows its orbit, the tilt of the earth's axis changes our relationship with the sun.

T F 14. The greatest intensity of solar radiation occurs during the early morning hours when the air is cleaner.

T F 15. As a general rule, a solar collector used for heating only should have a tilt equal to fiteen degrees plus latitude.

T F 16. The optimum tilt of a collector occurs when the angle of the collector is always the same as the incoming radiation.

Fill in the blank(s) with the word (or words) which most accurately completes the thought.

17. A passive system usually has _____moving parts and is not the _____of the people taking this course.

18. A concentrating solar collector best utilizes _____ solar radiation.

19. A chief disadvantage to the use of concentrating collectors involve the expense necessary to _____on the _____ throughout the day.

20. While a solar air system requires _____capital costs, _____energy is required during its life to move the _____ from the collector to storage for use than for a liquid system.

21. Which gives off the greatest quantity of heat: A-a gallon of water cooled from 210^{o} to 188^{o}F, or B-a gallon of water cooled from 48^{o} to 18^{o}F?_____

22. Of the absorption refrigeration currently in use, the _____ _____chillers appear to hold the most promise.

23. Through the use of a solar _____-_____engine, a device such as a heat pump could become a solar related device in both cooling and heating modes.

24. It is essential that the solar heating/solar cooling system provide the maximum possible return for the dollar invested based on savings over the _____, _____, and _____ of conventional heating systems.

25. Boston, Massachusetts receives 5"_____precipitation per year than Seattle, Washington.

26. The storage of inexpensive_____fuels make it imperative to design efficient solar heating systems.

27. Beside radiant (solar) energy, three other forms of energy useful to people are:_____,_____and_____

28. The electromagnetic spectrum of the sun's rays depicts_____ different types of radiation, but in this course only_____ _____ and_____are of interest.

29. The instrument used to measure solar energy is called a _____

30. British Thermal Units per square foot is expressed in abbreviated for as _____

31. To convert Langleys into British Thermal Units per square foot, multiply Langleys by _____

32. UV means _____ and is _____ wave length radiation.

33. With the outer space value of solar energy equalling 100 percent, _____ percent is the normal maximum reaching the earth.

34. The cooling capacity of one ton of ice is _____ BTU/h.

35. _____ energy would be intercepted if the collector were to track the sun across the sky.

36. The generally accepted tilt of a heating only collector is latitude plus _____ degrees.

37. Maximum solar intensity occurs at noon when the sun is due _____ in this hemisphere.

38. Atmosphere, vegetation, and physical barriers cause the potentially useful solar energy to _____ from location to location, month to month, day to day, and hour to hour.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

39. The surface temperature of the sun is approximately:
    a. 5,000°F.
    b. 10,000°F.
    c. 15,000°F.
    d. 30,000°F.

40. Langley/min is the abbreviation for
    a. calories per square centimeter
    b. calories per square centimeter per minute
    c. calories per cubic centimeter per Langley minute

41. The solar constant is equal to
    a. 1.940 Langley's/min.
    b. 428.7 BTU/(ft.^{2} h).
    c. all of the above
    d. none of the above

42. Which item is not a component of an all-air solar heating/solar cooling system?
    a. auxiliary furnace
    b. heating/cooling distribution system
    c. solar collector
    d. boiler
    e. cooling unit
    f. thermal storage unit

43. Based on the factors presented in this unit, it is essential that solar heating/solar cooling systems provide the user with
    a. comfort and safety
    b. maximum return for dollar invested
    c. a good looking unit
    d. snob appeal

AREA - SOLAR APPLICATION INSTALLATION

Unit 4 - Solar System Design Engineering

I. Instructional Objective

To present the basics of solar system operation. The relationships which must exist between the collector, storage unit, auxiliary furnace, pumps, fans, heat exchangers, and other vital parts of the total system are presented. Finally, the control system which regulates the flow of air and liquid through solar heating systems is discussed.

It is essential that the student develop the architectural perspective that allows a typical three dimensional solar space heating system to be visualized in a pictorial piping arrangement or in a single line mechanical layout. Both design formats are encountered industry-wide and the student will be well versed to intelligently describe each. The student will be able to construct these design graphics to scale to help assure a complete solar system at the time of installation. The student will also be able to recognize and implement the correct graphic symbol to represent system components in all diagrams.

Solar heating of domestic hot water (DHW) is growing rapidly in the United States. Many solar domestic hot water heating systems are available for new installations as well as retrofitting into existing homes. This lesson introduces the basic types of systems available, considers each of the principal components of the system individually, discusses the operation of these systems, presents information about sizing the components, and deals with the principal economic question which must be answered before deciding to purchase a solar domestic water heating system.

II. Reference Material

Lennox Solar (Vol. 1) Equipment Selection
Solaron Solar Energy Systems - Section 400 and 500
Solar Design Handbook
Design Criteria for Solar Heated Buildings - Chapter 5
Fundamentals of Solar Heating Lesson 7 and 8

III. Visual Aids

Lennox Slides (27-41), (97-118)
Lennox Worksheet Example
Sun Earth Slides 62-68

IV. Method - Performance Conditions

The slides are used to convey the basic design principles. They provide a working model which illustrates three important areas. The students, via discussion, should attempt to establish these: (1) spacial relationships must be duplicated in the design, (2) general knowledge of installation and component function is desirable and (3) drawings that are complete and to scale are the basis of the valuable bill of

materials list for each job. The students will be required to respond to symbols on the slides for a detailed description.

V. Outline

I. Engineering drawings
   A. Pictorials
      (1) description
   B. Mechanical layout
      (2) description

2. Symbols
   A. Components
      (1) check valve
      (2) circuit setter
      (3) gate valve
      (4) relief valve
      (5) filter
      (6) three-way valve
      (7) pump

3. Installation hints
   A. Filter in horizontal pipe
      (1) sedimentation bowl
   B. Gate valves
      (1) isolation of major components
         a. globe
            1. equivalent length
         b. consider circuit setter
   C. Circuit setter
      (1) establish flow rate prior to collector entry
   D. Pump
      (1) secure
      (2) eliminate vibrations
   E. Check valves
      (1) location

4. Bill of materials list
   A. Itemizing procedure
      (1) example

5. Design (systems engineering)
   A. Preliminary estimating techniques
   B. Criteria for sizing
   C. Heat loss
   D. Collector orientation
   E. Collector tilt
   F. Calculation procedure
   G. Water
      (1) flow direction
      (2) flow rate
      (3) pressure drop
      (4) piping and manifolding
      (5) slope of headers
      (6) pressure relief

(7) expansion contraction
(8) freeze protection
(9) overheating protection
(10) corrosion protection

6. Solar and standby system control interlock
   A. Collection sub-system
   B. Water drainback system (siphon or open drop)
   C. Glycol collector
   D. Heat exchanger design

7. Pump design
   A. Determine pumping head
   B. Glycol effect on flow rates
   C. Glycol effect on pumping head
   D. Glycol effect on pump curve
   E. Compression tank
   F. System leak and sludge protection and prevention

8. Design
   A. Air-air handling unit
   B. System description
   C. Motorized dampers
   D. Backdraft damper

9. Solar system vs. building heating requirements
   A. Collector orientation south
   B. Tilt
   C. Shading/solar window
   D. Flashing and mounting
   E. Structural considerations

10. Solar energy collection - water
   A. Types of solar heating - systems collector tech. data sheets
      (1) description
      (2) panel details
      (3) mounting details
      (4) dimension and performance
      (5) warranty
   B. Collector spacing
   C. Guide specifications

11. Collection tech. data - air
   A. Specification and performance data
   B. Air manifolding
   C. Dimensions of collector and perimeter flashing
   D. Typical collector arrays
   E. Spacing for flat roof/free standing

12. Sizing
   A. Sample calculations
   B. Conversion factors
   C. Sizing work sheet
   D. Auxiliary heating system and duct work
   E. Outside air - calculation procedure

13. F Chart calculations
    A. Space heating and domestic hot water sample calculation
    B. Worksheet
    C. Domestic hot water only, F Chart
    D. Sample calculations
    E. Worksheet
    F. Heating degree days
    G. Weather data
        (1) solar radiation
        (2) average daily temperature
        (3) each month

VI. Student Evaluation Parameters

1. Describe the five basic operating modes for air solar heating systems.
2. Determine which components of the systems should be operating and which valves or dampers should be open during each operating mode.
3. Describe the importance of eliminating air leaks in all air solar heating system.
4. Identify the safety devices required on the domestic hot water subsystem.
5. Identify the basic differences between air and hydronic solar heating systems.
6. Describe three different ways heat pumps can be coupled to solar heating systems.
7. Describe the three basic types of solar domestic water heating systems and identify the basic components of each.
8. Understand and be able to discuss the advantages and disadvantages of air versus liquid systems.
9. Describe the operating cycles of the three basic systems for heating domestic water.
10. Analyze the economic considerations which are important to the decision to purchase a solar domestic water heating system.
11. Student will be capable of working through sample load sizing problems such as introduced through Lennox slides.

VII. Sequence of Instruction

1. Read assigned reference material.
2. View slides
3. Discuss slides and work sample problems.
4. Take Unit 4 quiz.

Unit 4 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. When heating directly from the collectors of an all air system, the heated air normally passes through the storage unit before entering the space to be heated.

T F 2. Heating domestic water is possible by adding a fin tube heat exchanger in the air stream leaving the collector.

T F 3. A T/P valve is installed at the pre-heated domestic water tank to prevent overheating of this water.

T F 4. Ducts with insulation value of R-4 should be installed to reduce heat loss in an all air system.

T F 5. A bypass duct is always required in an all-air solar system.

T F 6. When storing heat with a hydronic solar heating system the storage pump is off.

T F 7. When heat is being stored in a closed loop hydronic solar heating system the collector fluid flows directly to the storage unit.

T F 8. The purpose of the purge cycle is to drain the fluid from the collector.

T F 9. The simplest installation of a heat pump in a solar heating system is to use the heat pump as an auxiliary heat source.

T F 10. A heat pump can be installed so it will draw heat from the solar storage unit.

T F 11. The collector pump will short-cycle if the "on" and "off" points on the differential thermostat are too close.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

12. One way to prevent scalding water from entering the domestic hot water line is to install a
    a. pressure/temperature relief valve
    b. drop line
    c. thermostatic mixing valve
    d. air cushion tank

13. A well designed all air solar system will have a pressure drop of approximately 0.3 inches of water in the
    a. collector
    b. storage unit
    c. duct system
    d. both A and B are correct

14. The collector loop of a hydronic solar system contains
    a. collector
    b. heat exchanger
    c. pump
    d. all of the above

15. If a heat pump is used for auxiliary heat, the "solar" water coil is installed upstream from the refrigerant coil to
    a. avoid higher head pressures on the compressor
    b. make installation easier
    c. to increase the heat output from the heat pump
    d. all of the above are correct

In the following completion questions place the correct number, word or phrase in the blank(s) provided with each question.

16. List the five basic modes of operation possible with all air solar systems:

    a. _____

    b. _____

    c. _____

    d. _____

    e. _____

17. The flow path of air through the storage unit when heat is being stored is _____ the air flow when heating from storage.

18. Why is air leakage more of a problem in all-air solar heating systems than in conventional forced air heating systems?

    a. _____

    b. _____

    c. _____

    d. _____

19. To achieve quiet operation, all blowers should be _____ driven.

20. Dampers on all air systems be fitted with _____ _____ seals for positive shut-off and smooth operation.

T F 21. Solar domestic hot water heating is presently more economical than whole house space heating.

T F 22. The direct heating/thermosiphon system is well suited to northern climate.

T F 23. Direct water heating systems require drains to be installed in the collector loop to prevent freeze damage.

T F 24. Indirect solar water heating collector systems have been developed to overcome the freezing problems of direct heating systems.

T F 25. Indirect water heating systems can use either air or liquid (hydronic) collectors.

T F 26. Double wall heat exchangers are generally required in liquid solar water heating systems.

27. The simplest form of the solar domestic water heating system is the
    a. indirect heating/thermosiphon
    b. direct heating/thermosiphon
    c. direct heating/pump circulating
    d. indirect heating/pump circulating

28. In a direct heating/thermosiphon system the water storage tank must be
    a. located 1 to 2 feet above the collector
    b. located 1 to 2 feet below the collector
    c. made of fiberglass
    d. larger than in any of the other systems

29. Excessive hot water is prevented from entering the domesting hot water service line by installing a
    a. check valve
    b. P/T valve
    c. an automatic drain valve
    d. thermostatically controlled mixing valve

30. To prevent excessive build-up of hot water or steam in the storage tank a
    a. check valve is installed
    b. P/T valve is installed
    c. an automatic drain valve is installed
    d. thermostatically controlled mixing valve is installed

31. Among the major advantage(s) of using air rather than water as a transfer medium are/is:
    a. freedom from freezing and boiling
    b. no risk losing expensive fluid in collector loop
    c. no risk of damaging leaks
    d. all of the above

32. The major disadvantage(s) of using air rather than water as a transfer medium is/are:
    a. larger collector required
    b. larger piping required to connect components
    c. more energy required to circulate air
    d. all of the above

33. Describe two disadvantages of direct heating/thermosiphon solar domestic water heating systems.

    a. _____

    b. _____

34. A _____ valve is installed in the collect loop of a solar domestic water heating system to release excessive pressure and allow any steam which may be created to escape.

35. Label each of the lettered components of the direct heating/pump circulating system shown at the right.

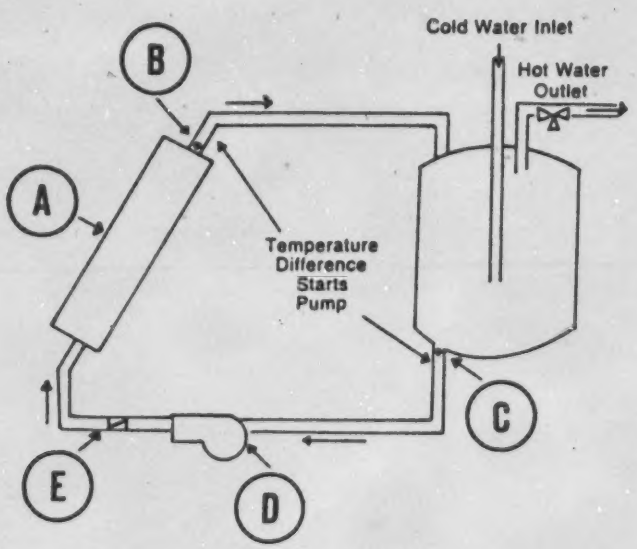
    a. _____

    b. _____

    c. _____

    d. _____

    e. _____



36. Using Table 8-1, calculate the daily BTU requirement for a family of four living in a three bedroom home which is supplied with service water at a temperature of 45°F. Assume that the desired temperature of the heated water is 155°F. _____

AREA - SOLAR APPLICATION INSTALLATION

Unit 5 - The Solar System

I. Instructional Objective

Introduction to several methods of selecting the size of the key components of a typical solar heating system. The techniques presented are based upon research data and provide varying degrees of precision, depending upon their levels of sophistication. Students will have the opportunity to consider several important economic factors and learn how they can affect the size of the most economical solar heating system. Also, in this lesson, information will be provided to help the student use a computerized system which is available to compute the size of the components required for a solar heating system.

The student will begin to think of the base line system, that is, solar space heating and hot water, in terms of functional subsystems. The subsystems will include the collector loop with purge capabilities, the storage loop, pre-heat for domestic hot water, an auxiliary heat source, and the electrical logic system. The student will be able to itemize all mechanical components in each subsystem and explain the purpose and operation of each device. In this manner, a general understanding of the interrelationship of subsystems to the overall solar system performance will result. It will be necessary for the student to recognize and associate graphic symbols to the exact system component as might be viewed on a mechanical layout of a base line system. In addition, the student will be required to adopt and utilize a new solar vocabulary when discussing system composition. Proper terminology is of paramount importance to help eliminate possible confusion in this new technology.

The student will learn about sizing the collector. Once the size of the collector is known, it is possible to compute the size of each of the remaining solar system components. Your previous experiences with forced air and hydronic heating systems will aid your study.

II. Reference Material

Lennox Solar (Volume 1) (Components and Operating Modes)
Solaron Solar Energy Systems, Section 600 Systems
Fundamentals of Solar Heating, Lesson 6
Installation Guidelines for Solar BHW Systems, Page 1-58
Solar Energy Handbook, Chapter 6
Sun Earth, Chapter 3

III. Visual Aids

Lennox Slide Presentation (42-73)

Component parts
A. Hand valve
B. Check valve
C. Circulation pump
D. Strainer
E. Circuit setter - balancing valve

F. Aquastat controller
G. Pressure relief valve
H. Differential controller and sensor
I. Return air limit
J. Air separators
K. Compression tank with airtrol
L. Collector
M. Heat exchanger
N. Three-way valve
O. Space heating coil
P. Purge coil
Q. Storage tank
R. Hot water coil

AP-3 Solar System Trainer - Lennox, or equivalent

AP-4 Solar System Trainer Kit - Lennox, or equivalent

RT-5 Solar Cycle Trainer - Lennox, or equivalent

IV. Method - Performance Conditions

The slides are used to introduce the integral components of each of the subsystems. The operation of the components is determined, both by slides and live component parts. Following questions and discussion over each subsystem, they are integrated into a complete, functional solar system. This information can be transferred to a mechanical layout of the solar hydronics using all appropriate symbols. Either the Lennox AP-3 or AP-4 or equivalent are convenient vehicles to show a compact system in terms of a mechanical orientation. The trainers also allow for descriptively illustrating fluid flow during operation. After completing this exercise the student should draw an understandable mechanical layout of the system. Throughout this presentation typical hydronic terminology is employed. NOTE: all of the aforementioned demonstrations can be built as a class project, dependent on funding available for course offerings.

V. Outline

1. The Solar System
   - A. Collector loop
     - (1) collectors
       - a. types
       - b. methods for removing heat
     - (2) air separator
       - a. purpose
       - b. baffles - velocity effect
     - (3) compression tank
       - a. expansion of fluid
         1. pressure effect
         2. relief valve
       - b. airtrol device
         1. operation
       - c. necessity for closed system

(4) centrifugal pump
- a. purpose
- b. design
- c. couplers
- d. lubrication
- e. motor sizes
- f. impellers
- g. cavitation
- h. air bound problems

(5) purge coil
- a. purpose
- b. forced convective
- c. convective

(6) circuit setter
- a. purpose
- b. indication settings
- c. test parts

(7) three-way valve
- a. operation

(8) strainer

(9) check valve

(10) piping
- a. type - reverse return
- b. connections

(11) fluid
- a. 50% Glycol
  - 1. properties
    - aa. density
    - bb. specific heat
    - cc. specific gravity
    - dd. pressure drops
    - ee. laminar flow
    - ff. turbulent flow

(12) heat exchanger
- a. single pass
- b. multi-pass
- c. reverse flow
- d. shell
- e. tube bundle
- f. temperature crossover

(13) Pete's plug

B. Storage loop - water or rock

(1) storage tank
- a. capacity

(2) space heating coil
- a. limit
- b. location

(3) heat exchanger

(4) centrifugal pumps

(5) check valve

(6) compression tank

C. Hot water preheat

(1) preheat coil

(2) water tempering valve

D. auxiliary heat
   (1) gas
   (2) oil
   (3) electric
   (4) heat pump
E. Electrical logic system
   (1) differential controller (3K)
      a. sensors
   (2) aquastats
      a. purge (5K)
      b. storage (4K)
   (3) relays
   (4) limit
   (5) valve
   (6) pump

2. Electric Logic System
   A. Differential controller (3K)
      (1) temperature sensors
         a. collectors
         b. storage
      (2) directs heat flow in system
         a. to storage
         b. to space heating coil
         c. to purge
   B. Aquastats
      (1) storage (4K)
      (2) purge (5K0
   C. Return Air Limit
      (1) safety
   D. Control center
      (1) relays
   E. Thermostat
   F. Three way valves
      (1) energized position

3. System Operation
   A. Heat Collection
      (1) overview of heat distribution
         a. storage
         b. space heating
         c. purge

4. Mechanical Layout
   A. Illustration
      (1) symbols
         a. hydronic components

5. Terminology
   A. Heat transfer
   B. GPM
   C. CFM
   D. BTU
   E. Insulation
   F. Fluid

Additional Components to Discuss

I. Liquid system
   A. Antifreeze solution
   B. Heat exchanger
   C. Purge coil
   D. Filters and strainers
   E. Air separator
   F. Compression tank fittings
   G. Compression tank
   H. Centrifugal pump
      (1) pump sizing
   I. Storage tank
      (1) tank sizing
   J. Immersion well
   K. Solar heat coil
   L. Tempering valve
   M. Pressure relief valve
   N. Balancing valve
   O. Check valve
   P. Gate valve
   Q. Three way valve
   R. Air vent
   S. Test plug and gauge adapter
   T. Copper tubing
      (1) sizing
   U. Insulation

II. Air
   A. Collectors
   B. Internal manifold
   C. Air handling equipment
   D. Motorized dampers
   E. Back draft dampers
   F. Duct work
      (1) sizing
      (2) sealing air tight
   G. Insulation

III. Modes of Operation
   A. Heat from collector to heated space
   B. Heat from collector to storage
   C. Heat from storage to heated space
   D. Summer water heating
   E. Second stage heat back-up: solar and heat pump
   F. Second stage heat pump, no collector or stage heat (back up elect. resistance may be 3rd stage if needed)

IV. Systems
   A. Space Heating
      (1) one zone
      (2) with air conditioning/or continuous air circulation
      (3) swimming pool water
      (4) heat pumps
      (5) two zones

(6) two or more zones
(7) without storage
(8) process fluids
(9) outside air
(10) water
(11) off peak storage

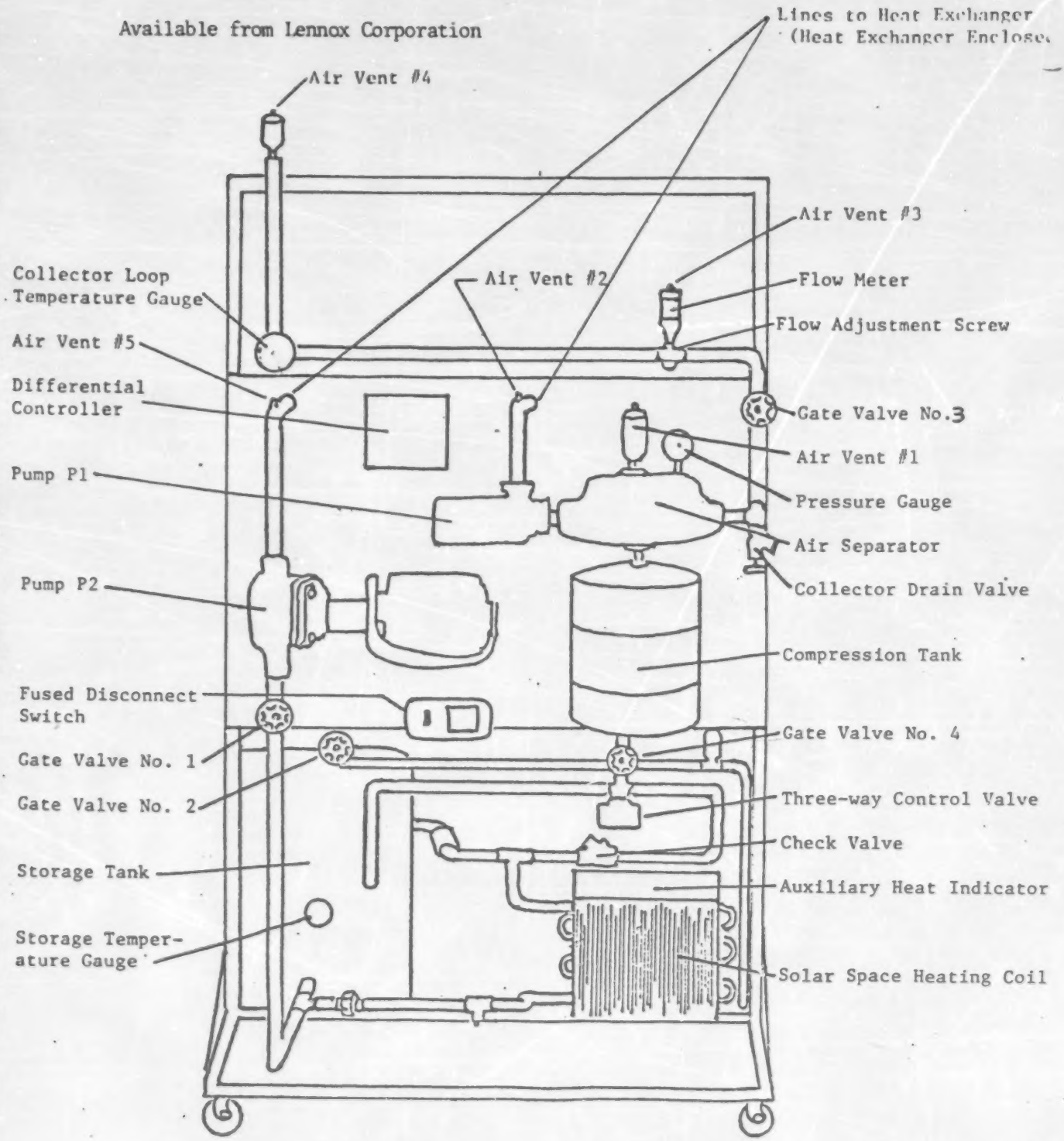
VI. Student Evaluation Parameters

1. Identify ten components of a typical solar heating system
2. Define the term "life-cycle-cost."
3. Use tables to determine the collector size for typical homes.
4. Identify the more important economic factors in sizing solar heating systems.
5. Calculate the size of the heat storage unit required for a typical collector.
6. Calculate the size of the pumps or fans which circulate water and air through the collector.
7. Prepare the input for a computer program which will compute the size of solar system components.

VII. Sequence of Instruction

1. Read assigned reference materials.
2. View slide presentation.
3. Discuss all components in class.
4. Demonstrate and show all components in class.
5. Take Unit 5 Quiz.
6. Take Unit 4 and 5 Exam.

Available from Lennox Corporation



RT-5 SOLAR CYCLE TRAINER - Available from Lennox Corporation

Introduction

There are many mechanical and electrical variations that can occur in a solar space heat/domestic hot water system. Fluid flow can be routed in numerous ways to:

a. use the sun's energy directly for heating;

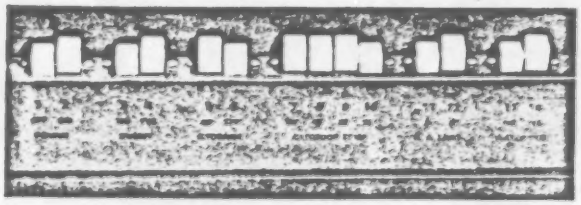
b. store the sun's energy to be used at a later date;

c. use hot water from storage for space heating;

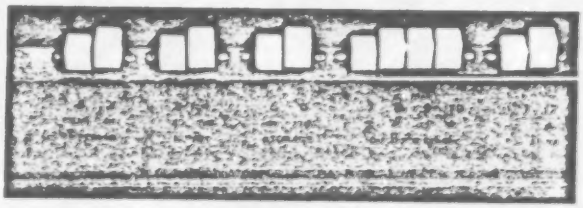
d. use hot water from storage for domestic water heating;

e. rid the system of excess heat.

The RT-5 Solar Cycle Trainer permits the instructor to isolate the flow patterns and discuss what is happening. The EB-5 Schematic Trainer is designed so electrical control sequences can be programmed to match these patterns shown on the RT-5.



Switch Panel On The RT-5



Switch Panel On The EB-5

Switch Identification for RT-5 and EB-5

Switch 1	Power Off
Switch 2	Power On
Switch 3	No Sun
Switch 4	Sun
Switch 5	Storage, 80°F or Below
Switch 6	Storage, 170°F
Switch 7	Outdoor Temperature 70°F
Switch 8	Outdoor Temperature 45°F
Switch 9	Outdoor Temperature 20°F
Switch 10	Outdoor Temperature 95°F
Switch 11	Open Solar Coil Limit (R.A. Limit)
Switch 12	Closed Solar Coil Limit (R.A. Limit)
Switch 13	No Water Use
Switch 14	Water Use

(Switches 13 and 14 are on the RT-5 only).

AP-3 SOLAR SYSTEM TRAINER - Available from Lennox Corporation

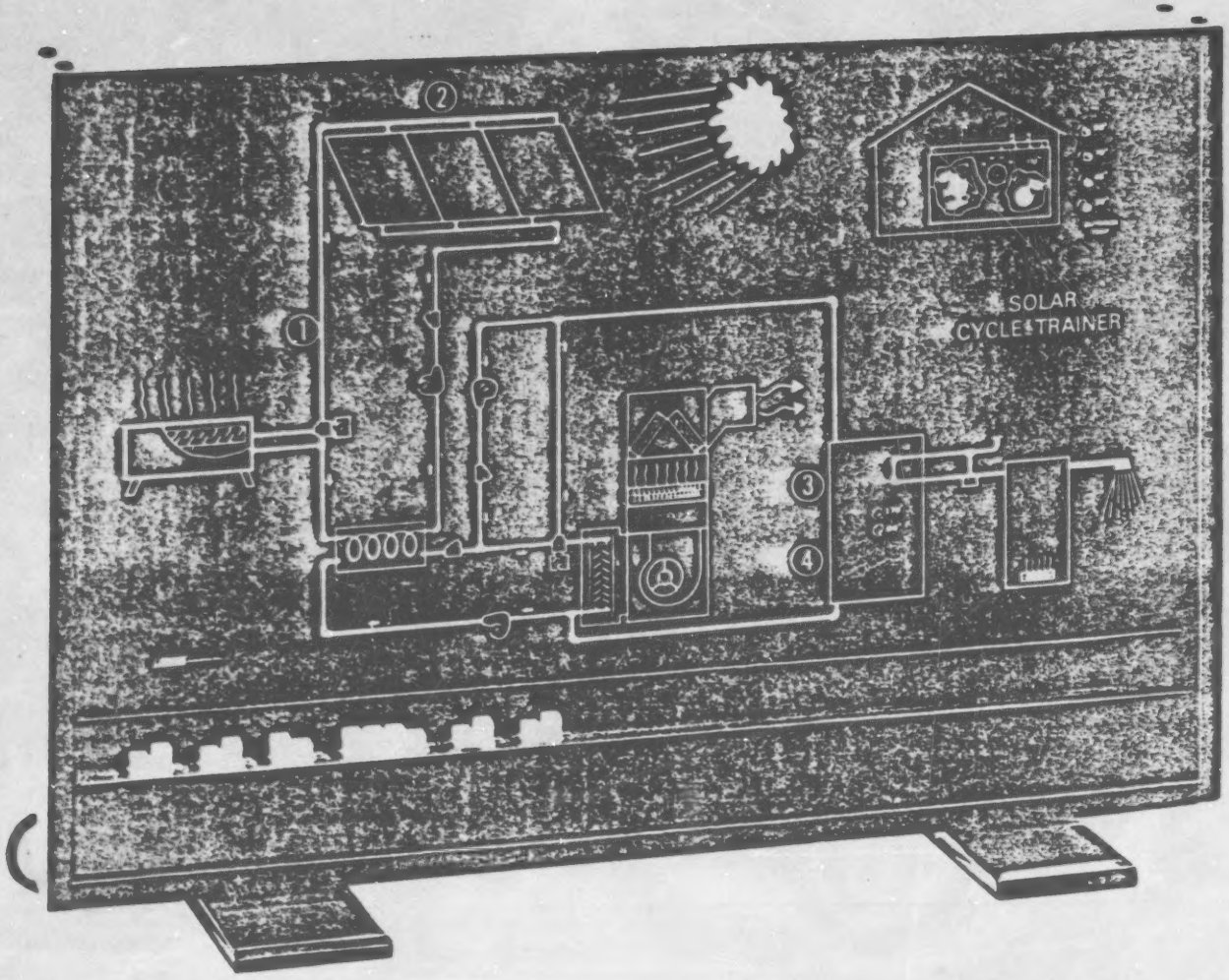
Introduction

The AP-3 Solar System trainer is designed to acquaint the student with fundamentals of solar hydronic heating systems. The trainer aids the student in acquiring an understanding of individual components and the interrelation of these components when applied to solar heating. The trainer shows the student how pressure and temperature affect system operation. The student also learns charging procedure and system startup.

Trainer Design

The AP-3 is a portable, self-contained unit shipped completely assembled. The collector is secured to the trainer frame at a tilt angle of 52^{o}. The trainer may be moved to any convenient location where solar radiation is available. The trainer will also function under artificial light, such as heat lamps. See "Components", "Operating Modes" and "Control" sections of Lennox Solar Manual for further explanation. Refer to Trainer Parts Diagram and Flow Loop Diagram for location of components and flow loop identification.

Available from Lennox Corporation



RT-5 SOLAR CYCLE TRAINER

(Locations of Sensors)

1. **Purge Aquastat Sensor**
2. **Collector Sensor (3K)**
3. **Storage Aquastat Sensor (4K)**
4. **Storage Sensor (3K)**

Unit 5 - Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. The shortage of fossil fuels is one reason why consumers are likely to purchase solar heating systems.

T F 2. When determining the size of solar heating system component, the heat storage unit is sized first and all other components are sized in relation to it.

T F 3. For heating only, the optimum angle of a solar collector with respect to the horizon is local latitude plus 15°F.

T F 4. Counterflow design of heat exchangers decreases heat transfer.

T F 5. The higher the approach temperature of the heat exchanger, the higher the efficiency.

T F 6. An air cushion tank provides the normal expansion of the liquid in a liquid solar heating system.

T F 7. The diaphragm in an air cushion tank prevents the air in the tank from mixing with the water.

T F 8. As the costs of natural gas, fuel oil and other forms of fossil fuel energy increase, it becomes less economical to install a solar heating system.

T F 9. The additional investment in solar heating equipment will increase the value of a home and is likely to increase the annual tax and insurance bills.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

10. Which of the following are considered when life-cycle-costing is applied to the design of a solar heating system?
    a. initial cost of the system
    b. expected life of the system
    c. cost of auxilliary energy
    d. all of the above are considered in life-cycle-costing

11. A collector which is oriented 30° west of south will operate at an efficiency of _____
    a. 0.93
    b. 0.98
    c. 0.90
    d. 0.97

12. An air solar system with 400 square feet of collector will require a storage unit containing _____cubic feet of pebbles.
    a. 200-400
    b. 150-300
    c. 250-600
    d. 450

13. A heat exchanger is installed in a liquid solar heating system to:
    a. increase the efficiency of the system
    b. prevent the collector fluid from boiling
    c. separate collector loop fluid from the storage loop fluid
    d. heat domestic hot water

14. A clearinghouse to obtain complete, up-to-date information about solar systems is:
    a. HUD
    b. National Solar Heating and Cooling Information Center
    c. ERDA
    d. none of the above

15. The FCHART collector sizing technique is
    a. very simple to use
    b. a very detailed sizing procedure
    c. available to customer through some collector manufacturers
    d. both B and C are correct

16. A procedure developed at Colorado State University for sizing collectors is based upon
    a. the FCHART system
    b. rules-of-thumb
    c. heat exchanger size
    d. economic analysis

17. Presently, for most locations the most economically solar heating installation will replace _____ percent of the fossil fuel energy requirement.
    a. 50-70
    b. 40-80
    c. 60-90
    d. 50-55

18. The ERDA computer program which contractors can use to determine optimum collector size and obtain heat loss calculation is known as
    a. FCHART
    b. Relative Areas Analysis
    c. Solocost
    d. Life-cycle-costing

In the following completion questions, place the correct number, word, or phrase in the blank(s) provided with each question.

19. A home located in Seattle, Washington has a heat loss of 60,000 Btuh for 20^{0}F average outside and 70^{o}F average inside temperature. What size collector will be required if 50% of the energy requirement is to be replaced by solar energy using a liquid system and collector tilt of 53^{o}? Use Table 2-10 in SMACNA Standards.

_____sq ft.

20. One of the simplified procedures outlined in this lesson provided a separate divisor for air and liquid systems. Also, two choices of collector tile and three choices of percent of solar contribution are given. What is the title of the document where these data can be found?

_____

21. Simplified solar collector sizing procedures do not all produce the same results. Why is this so?_____

What must the designer/technician know when applying any of these techniques?_____

22. List ten factors which affect the life-cycle-cost of a solar heating system.

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

23. Referring to the sample Solocost analysis, Figure 6-8, identify the values for the following input parameters:

a. Collector tilt_____degrees

b. solar system fixed initial cost $_____

c. property tax rate_____

24. Referring to the output of the sample Solocost analysis, Figure 6-8, identify the following:

    a. initial solar investment $_____

    b. collector size _____square feet

    c. annual proportion of load provided by solar_____%

    d. rate of return on net cash flow_____%

Unit 4 and 5 Examination

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Solar heating equipment manufacturers may use their own sizing procedures.

T F 2. There is only one accurate way to determine the collector size for either the air or liquid system.

T F 3. A fixed collector array will satisfy the same percentage of the heat demand consistantly in all buildings in a given location.

T F 4. Doubling the size of the collector means doubling the heat output.

T F 5. Counterflow between hot and cold fluids improves heat transfer.

T F 6. Modern expansion tanks may be open to the atmosphere.

T F 7. Typically there are three blowers in an air system.

T F 8. Minimizing blower horsepower and air leaks are important considerations in an air system.

T F 9. Properly designed, the auxilliary system operates more hours per day than the collector loop.

T F 10. List duct coil BTU ratings may be reduced by non-uniform air velocity over coil.

T F 11. Sensors are placed at the inlet and outlet of the collectors for system operating purposes.

T F 12. In a closed loop hydronic system, more than one pump may operate at a given time.

T F 13. A heat pump can provide both heating in winter and cooling in summer.

T F 14. Because of excessive cost, DHW systems should not be installed alone.

T F 15. The thermosiphon system requires a low speed circulating pump.

T F 16. The thermosiphon system would be simple to operate in Florida.

T F 17. Safety valves are required for thermosiphon DHW systems.

T F 18. When heating DHW, the auxiliary system should be used only when solar insulation is insufficient.

T F 19. A relief valve to relieve pressure must be plumbed to an open drain.

T F 20. Air system collectors are larger than liquid system collectors when used for DHW of similar capacity.

T F 21. Almost any type of heat exchanger meets the code for DHW systems.

T F 22. By designing a 60% January hot water demand system, it would accommodate almost 100% of the June demand.

T F 23. There are numerous styles of heat exchangers.

Fill in the blanks with the word (or words) which most accurately completes the thought.

24. As a rule of thumb, the collector area required for space heating is equal to_____the floor space being heated.

25. The FCHART is a table to determine_____ _____

26. To accommodate the expansion of water in a closed loop system, _____ _____ _____tank is installed.

27. PSIG means _____ _____ _____ _____ _____

28. When heating from storage, the auxiliary system operates only during _____stage demand of thermostat.

29. Collector efficiency at times of both high and low insolation may be increased by_____ _____ pumps.

30. A reasonable rate of consumption for DHW is _____gallons per person per day.

31. List the four essential solar system operating modes.

a._____

b._____

c._____

d._____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

32. Typical collector efficiency for DHW is probably
a. 10% c. 70%
b. 40% d. 100%

33. When justifying solar installation for economic purposes, the expense most applicable is the:
    a. cost of equipment
    b. cost of labor
    c. tax break
    d. life-cycle cost

34. Optimum tilt angle for solar heating is latitude plus_____degrees.
    a. 0
    b. 5
    c. 15
    d. 30

35. Optimum tilt angle for DHW is latitude plus_____degrees.
    a. 0
    b. 5
    c. 15
    d. 30

36. The desired heat exchange approach temperature is:
    a. 0
    b. 10
    c. 20
    d. 30

37. Air cushion tanks can be located a few feet
    a. above the collector
    b. below the collectors
    c. above the storage unit
    d. below the storage unit

38. To prevent water from flashing to steam at the top of a collector, the
    a. static pressure is increased
    b. static pressure is decreased
    c. air vent is closed
    d. balance valves are adjusted

39. A diaphragm style air cushion tank allows for using_____cushion tanks.
    a. larger
    b. smaller

40. When ethylene glycol is used at a 50% concentration, expansion tanks must be_____in size.
    a. increased
    b. reduced

41. In the summer, when there is no immediate heat demand for DHW, the air system collector loop:
    a. continues to circulate hot air
    b. continues to heat the water
    c. exhausts to the atmosphere
    d. overheats the collector

42. The component that prevents scalding DHW water temperatures is:
    a. a heat controller
    b. a mixing valve
    c. an air vent
    d. the dual thermostat

43. Total pressure loss in an air system may be as high as _____inch of water.
    a. 0.3
    b. 0.6
    c. 0.9
    d. 1.0

44. A common air velocity inducts would be_____feet per minute.
    a. 200
    b. 400
    c. 800
    d. 1200

45. The least effective low temperature liquid space heat system with solar assistance is the:
    a. liquid to air unit
    b. hydronic baseboard unit
    c. heat exchanger unit
    d. low pressure storage unit

46. When the collector loop cannot supply enough heat directly the
    a. house gets cold
    b. storage unit heat is used
    c. auxilliary heat is used
    d. circulating pumps operate in reverse

47. A disadvantage of a heat pump as auxiliary heat may be:
    a. ineffective movement of the liquid
    b. use of unstable liquids
    c. large space that the pump occupies
    d. cost of electricity required to operate them

48. Differential thermostats are typically set to start when the temperature difference between collector and storage is about_____
    a. $3^{o}F$
    b. $6^{o}F$
    c. $10^{o}F$
    d. $20^{o}F$

49. The simplest DHW system to operate is the _____system.
    a. thermosiphon
    b. liquid circulating
    c. air circulating
    d. combination of B and C

50. The most difficult DHW system to integrate into the structure is the _____system.
    a. thermosiphon
    b. liquid circulating
    c. air circulating
    d. combination of B and C

51. Check valves prevent:
    a. overheating the collector
    b. short cycling
    c. reverse circulatin
    d. system drain-down

52. In the direct heating/pump circulating DHW system, _____prevents freezing.
    a. antifreeze
    b. reverse circulation
    c. high speed pump action
    d. a drain-down valve

53. The first concern in sizing is:
    a. heat storage unit
    b. air handler
    c. collector
    d. heat exchanger

54. In the indirect heating/pump circulation DHW system,_____prevents freezing.
    a. antifreeze or special fluid
    b. reverse circulation
    c. high speed pump action
    d. a drain-down valve

AREA - SOLAR APPLICATION INSTALLATION

Unit 6 - The Collector

I. Instructional Objective

The collector, which comes in contact with solar radiation, is the topic for Unit 6. Explanations are given of (1) various types of collectors, (2) how collectors are designed and manufactured, and (3) how collectors transfer the solar radiation into hot air or liquid.

A study of the solar collector, commonly referred to as the "heart" of the solar assisted heating system. Regardless of the fluid (air or liquid) which will be moved through the collector, the functions are the same; namely to collect solar radiation and convert it to heat energy. This unit deals with the concepts of the function and design.

In this unit the student will be introduced to various types of collectors, such as air collectors, fluid collectors, and focusing collectors. The advantages and disadvantages of each will be pointed out and the student will be required to itemize these. Attention will be given to flat plate collector construction, the various ways collector losses occur and the methods implemented to minimize those losses, and the variables affecting overall collector efficiency. It is important for the student to be able to read collector performance curves and use this information as a base for comparing collectors. The student will calculate collector efficiencies utilizing both performance curves and collector heat removal data. The student will calculate the number of collectors necessary for space heating and domestic hot water requirements for typical residential dwellings. The monthly percentage of load f-chart method will be employed. Other methods of determining collector area will be illustrated. The student will focus on payback aspects of solar heating systems and the criteria that influence solar heating decisions. There is additional terminology that is assimilated into the student's solar vocabulary.

II. Reference Material

Lennox Solar (Vol. I) Solar Energy Collector
Solaron Solar Energy Systems - Section 200 and 500
Fundamentals of Solar Energy - Lesson 3
Installation Standards (4-1)
Solar Decision Book, Chapter 9 and 10
Solar Energy Handbook - Chapter 5

III. Visual Aids

RP Products Collector (Suncell)
Lennox LSC18-1S collector
Slides Lennox (27-41)
Collector calculation forms
Sun Earth Slides 27-32

IV. Method Performance Conditions

The slides are used to stimulate class discussion concerning various types of collectors. The students then can formulate a comparison chart listing the features of each type. The slides depict engineering advances that result in increased efficiency of the collector. A collector is disassembled to illustrate the construction of the collector. Sample problems, completed as a group activity, can be used to demonstrate collector efficiency. The problems can be compared to the performance curves in towns of heat removal. The worksheets allow everyone in the group to tabulate the information necessary to calculate the collector surface area and annual load capability. Adequate sample problems should be completed so everyone is confident using the material. A brief explanation covering the sizing method is given. A group discussion of payback periods, cost versus performance, and procedures for estimating these variables should conclude this segment using any available worksheets or methods. Proper terminology is continuously stressed.

V. Outline

I. Collectors
- A. Air
  - (1) vacuum tube
  - (2) flat plate
    - a. solaron
  - (3) window slabs
- B. Fluid
  - (1) glycol-water mix
- C. Focusing
  - (1) concave concentrator
    - a. absorber
  - (2) lens
  - (3) beam radiation
- D. Criteria
  - (1) cost
  - (2) weight
    - a. wind load
  - (3) roof
    - a. area
    - b. strength
  - (4) future uses
    - a. absorption cooling
- E. Construction
  - (1) insulation
  - (2) transparent covers - low iron (Fe)
    - a. etching
  - (3) substrate - absorber plate
    - a. absorptance
  - (4) selective coatings
    - a. reradiation characteristics
    - b. colors
  - (5) manifolding ports
  - (6) weather resistance

F. Methods of heat loss
   (1) reflectance losses
   (2) transmission losses
   (3) convection losses within the collector
   (4) reradiation losses
   (5) ambient losses
G. Performance curves and efficiencies
   (1) inlet fluid temperature
   (2) ambient temperature
   (3) solar radiation (Q inc)
   (4) intercept (FR) T
   (5) slope (FR) UL
      a. comparing collector efficiencies
   (6) heat removal rate
H. Specifications
   (1) flow rate
      a. SR-1 Dowtherm
         1. -34°F F.P
         2. 0.25 Centripoise @ 160°F
         3. 232°F B.P.
         4. thermal conductivity 0.23 BTU/16°F
   (2) stable 850°F
   (3) areas
   (4) weight
   (5) emessivity -0.10
   (6) transmittance -0.96
   (7) absorptivity -0.94
I. Collector sizing
   (1) short form method
      a. LC factor
      b. SA/L
      c. degree-day (U_A)
   (2) worksheets I, II, IIa fraction of annual load-monthly base
J. Payback
   (1) escalating fuel prices
   (2) interest rates
   (3) operating cost
   (4) installation cost
   (5) maintenance
   (6) taxes
K. Terminology
   (1) slope
   (2) intercept
   (3) thermal conductivity
   (4) degree day
   (5) selective coating
   (6) shortwave radiation
   (7) longwave radiation
   (8) reflectance loss
   (9) incident flux (Qinc)
   (10) f-chart
   (11) density
   (12) specific heat
   (13) specific gravity
   (14) centipoise
   (15) emessivity

2. Focusing collectors
   A. Concentrator
   B. Absorber

3. Flat Plate Collector
   A. Construction
   B. Transparent covers
   C. Absorber plate
   D. Liquid Collector
      (1) fluids
   E. Air collector
   F. Insulated box and frame
   G. Collector performance
      (1) intercept
      (2) slope
      (3) curves
   H. BTU capacity of collector
   I. Comparison between liquid and air
      (1) advantage liquid
      (2) disadvantage liquid
      (3) advantage air
      (4) disadvantage air
   J. Summarize

VI. Student Evaluation Parameters

1. Explain the differences between flat plate and concentrating collectors.

2. Identify the differences in how air and liquid collectors are designed.

3. Describe the operating principles of various components in the collector.

4. Recognize different absorber plate designs and method of manufacture.

5. Describe total mechanics in construction of collectors.

VII. Sequence of Instruction

1. Read all reference material.

2. View all slides.

3. Work with demonstrator collectors

4. Discuss panel design and construction

5. Take Unit 6 quiz.

Unit 6 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Concentrating collectors "funnel" the heat to the absorber.

T F 2. Concentrating collectors pivot during the day.

T F 3. Flat plate collectors can be placed on any side of the roof.

T F 4. Diffuse radiation is unimportant to solar heating.

T F 5. Flat plate collectors are more popular than concentrating collectors.

T F 6. Flat plate collectors are most efficient at noon.

T F 7. Heat energy is the result of solar insolation.

T F 8. Most radiation that strikes the cover is absorbed by the glass.

T F 9. "Long wave conversion" reduces reradiation losses through glass covers.

T F 10. Plastic is a better material than glass for cover plates.

T F 11. The average annual outdoor temperature may determine the number of cover plates needed on a collector.

T F 12. Any kind of glass is as good as another for cover plates.

T F 13. Most efficient collectors have a vacuum between plates.

T F 14. Black paint is not applied to aluminum absorber surfaces.

T F 15. Absorber plates have absorptivities of 60% or less.

T F 16. Liquid collectors are larger than air collectors because of the space needed for piping.

T F 17. Fluid travels upward in all types of liquid collectors.

T F 18. A 30 psi system is classified as a low pressure system.

T F 19. Fluid tubes are always attached to the top surface of the absorber plate.

T F 20. Antifreeze can be used in liquid solar collectors as in automobile radiators to avoid freeze up.

T F 21. Electrolysis is more apt to occur in an air system.

T F 22. Polyurethane foam is the only insulating material for collectors.

T F 23. Since wood rots, collector frames should be made only of metal.

T F 24. Air through a collector array travels from the top of the roof toward the eave.

T F 25. Collectors do not need to be attached flat against the roof.

T F 26. Outdoor temperature can affect collector efficiency.

T F 27. A high temperature at the collector inlet will reduce collector efficiency.

T F 28. Data for collector efficiency are collected at or near noon.

Fill in the blanks with the word (or words) which most accurately completes the thought.

29. Two basic types of collectors are _____ and _____

30. The two transfer systems contain _____ and _____

31. The parts of a solar collector are:

1. _____

2. _____

3. _____

4. _____

5. _____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

32. Liquid flow rates through collectors are established near which number of gallons per minute?
a. .01 gpm/sq ft
b. .02 gpm/sq ft
c. .003 gpm/sq ft
d. .004 gpm/sq ft

33. Flow rates through air collectors are established near which number of cubic feet per minute?
a. 12 cfm/sq ft
b. 9 cfm/sq ft
c. 6 cfm/sq ft
d. 3 cfm/sq ft

34. The average absorber plate temperature is typically:
    a. 100°F.
    b. 150°F.
    c. 200°F.
    d. 250°F.

35. Heat energy that is visible is above
    a. 200°F.
    b. 500°F.
    c. 800°F.
    d. 1000°F.

36. The "blackbody" refers to the:
    a. collector frame
    b. absorber plate
    c. insulation
    d. none of the above

37. The main disadvantage of plastic covers is poor:
    a. heat transmission
    b. sheet stability
    c. sealing qualities
    d. light transmission

38. Various manufacturers of air system collectors use _____ to increase conductivity.
    a. insulation
    b. slow speed blowers
    c. polished duct work
    d. fins

39. Sketch the tube patterns in the rectangle representing three collector designs.

Serpentine Grid, direct Grid, reverse

AREA - SOLAR APPLICATION INSTALLATION

Unit 7 - Storage

I. Instructional Objective - Comparison of Storage Materials
Unit 7 is a study of the heat storage unit of a solar assisted heating system. Regardless of the fluid (air or liquid) which will be used as the heat transfer medium, the functions are the same; to store heat for circulation at night or during times of low solar insolation. This unit deals with the concepts of the function and design but not specifications that a manufacturer or contractor would use for a given heat storage unit.

II. Reference Materials
Proceedings of Solar Energy Storage Options, Vol. #1 & 2
Installation Standards, Solar 10-1
Fundamentals of Solar Heating, Lesson 4
Solaron Installation Manual, Heat Storage Residential and Commercial

III. Visual Aids
Tours of Existing Storage
Lennox Slides 67 and 75
Overheads of Suncell Storage Systems

IV. Method Performance Conditions
The students, by means of review, are called upon to draw the different types of storage systems for water and air type collectors. All components should be labelled. The necessity for insulating and tight sealing of all components should be discussed and stressed. A small mockup of storage system should be designed using proper materials and fabricating procedures.

V. Outline
I. Air
  A. Residential
    (1) heat storage unit, principles of
      a. concrete construction
      b. wood construction
    (2) sizing
    (3) rock sizing
    (4) attachment to system
    (5) metal lath
    (6) bond beam block
    (7) transite or spiral duct details

(8) construction
- a. calculate size
- b. determine location
- c. excavate if necessary
- d. footings
- e. construct walls
- f. install tie rod
- g. seal interim air tight
- h. install insulation
- i. install floor air system
- j. install diamond mesh
- k. obtain right size rock
- l. clean rock
- m. install rock (carefully)
- n. caulk and install lid

2. Commercial
   A. Same as above except sizing methods differ

3. Water
   A. Sizing the tank
   B. Placement of tank
   C. Insulation of reservoir

VI. Student Evaluation Parameters

1. Identify what material is used for heat transfer mediums.
2. Explain the concepts of sizing a heat storage unit.
3. Solve problems of storage unit sizing.
4. Discuss where storage units can be placed.
5. List factors that affect the advantages and disadvantages of different kinds of heat storage units.
6. Identify advantages and disadvantages of various heat storage practices.
7. Describe the materials used in manufacture and in installation practices for heat storage units.

VII. Sequence of Instruction

1. Read all reference materials.
2. View all overheads and slides
3. Discuss different solar storage options and designs.
4. Fabricate a storage system.
5. Take Unit 7 quiz.

Unit 7 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. All substances can absorb or give off heat.

T F 2. There is approximately six hours difference between typical winter and summer solar exposure.

T F 3. Rock requires less storage space because it is harder.

T F 4. Water and air are the only substances used for heat storage.

T F 5. To retain a comparable amount of heat energy, wax requires a larger heat storage tank than water.

T F 6. Phase change storage systems are not presently used as much as sensible heat storage systems.

T F 7. The best place to locate a heat storage unit is outside the building because it would not take up living space.

T F 8. An attic is an ideal location for a heat storage unit.

T F 9. The only problem with placing a storage unit above ground and outside is its poor appearance.

T F 10. A storage unit can be "too large" for a given system.

T F 11. To warm a space evenly requires a heat storage unit.

T F 12. A reasonable capacity for a liquid storage tank is up to two gallons of water per square foot of collector surface.

T F 13. Heat storage system sizes are calculated according to the coldest possible temperature in a given locality.

T F 14. One way to account for heat from internal sources when calculating daily heat demand is to lower the estimated inside temperature 5^{o}F.

T F 15. A heat storage unit should be adequate for an overnight supply of energy.

T F 16. A heat storage/collector system cannot be economically sized to supply a 100% annual heat load.

T F 17. The liquid storage tank must be heavily insulated.

T F 18. Watertight connections are easy to make for concrete tanks.

T F 19. Almost any fiberglass tank will be satisfactory to store heated water.

T F 20. Several small tanks may be as practical as one large tank for liquid storage.

T F 21. A storage unit that provides 50% of the heat demand is about the maximum size that can be built economically.

Fill in the blanks with the word (or words) which most accurately completes the thought.

22. An alternative to sensible heat storage is a _____ _____ _____

23. Changing one pound of ice to steam requires _____BTUs.

24. Attic heat storage could be used for a _____system when heating _____ _____ _____

25. Sensible heat storage systems usually use _____or _____as the storage material.

26. The size of the storage unit depends on the size of the _____ and the _____

27. It is inadvisable to use an aluminum collector without protection because of corrosion from _____

28. The liquid storage unit that is the most expensive to install would probably be made of _____

29. Pebbles for an air system storage unit are about _____ in diameter.

30. Two types of pebble beds are _____and_____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

31. The specific heat of water is:
    a. one degree
    b. one BTU
    c. one BTU per pound
    d. one BTU per pound per degree F rise

32. Phase change refers to:
    a. BTUs of insolation
    b. heat of fusion
    c. loss of BTUs
    d. weather changes

33. An advantage of phase change materials is that they:
    a. absorb more heat than water
    b. rarely need to be replaced
    c. are inexpensive
    d. insulate easily

34. A "too small" storage unit
    a. increases collector efficiency
    b. reduces collector efficiency
    c. saves money in construction
    d. wastes little or no heat

35. A reasonable capacity for an air system storage unit is up to_____ cubic feet of rock per square foot of collector surface.
    a. one
    b. two
    c. five
    d. ten

36. Thermal stratification in a pebble bed means that:
    a. the temperature of the bed is constant
    b. there are layers of varying temperature
    c. hot air is heavy
    d. dirt prevents heat absorbing

37. Three advantages of storing liquids are that:

    a._____

    b._____

    c._____

38. Five disadvantages of storing liquids are that:

    a._____

    b._____

    c._____

    d._____

    e._____

39. Some advantages of the hot air storage system are that:

    a._____ c._____

    b._____ d. _____

40. Disadvantages of air storage units are that:

    a._____

    b._____

    c._____

41. Three materials commonly used to construct liquid storage units are:

    a._____

    b._____

    c._____

(Refer to SMACNA Standards for questions 42-44).

42. The lowest likely temperature for 99% of the total winter hours in Fargo, North Dakota is_____

43. Cleveland, Ohio is likely to have a minimum temperature of _____ during 97½% of the winter hours.

44. The average winter temperature in Wilmington, North Carolina is _____

AREA - SOLAR APPLICATION INSTALLATION

Unit 8 - Electrical System

I. Instructional Objective

Unit 8 is a study of the various controls and specialty items of a solar assisted heating system. Blowers and dampers move and divert air in an air system. Centrifugal pumps and valves move and divert liquids in a liquid system. Many of these controls are electrically operated and, for the most part, are made-up of components commonly used by electricians, plumbers, and/or sheet metal workers in the heating-cooling industry.

The student will become accustomed to the mechanical modes of operation and the electrical devices that result in these varying flow patterns. It is a necessity to know the exact flow path of fluid through all subsystems in each mode of operation. The student will be able to trade fluid or air flow through the solar piping or duct arrangements. In addition, the student will follow through electrical schematic wiring diagrams to gain an understanding of the electrical logic systems. Wiring diagrams will correspond to each mode of operation.

II. Reference Materials

Lennox Solar (Vol. I) Control
Fundamentals of Solar Heating - Lesson 5
Installation Standards Solar - Section 6-1
Solar Decision Book - 17
Installation Guidelines for Solar DHW Systems - page 65
Solaron Solar Energy Systems - Air-Section 500 and 600
DOE Solar Design Hand Book Chapter 5-V

III. Visual Aids

Storage aquastat
Solar coil limit
Three-way valve
Worksheets
Differential controller
Purge aquastat
Pumps
Thermostat
Plug-in relay
Lennox Slides 82-96
EB-Lennox Schematic Trainer or equivalent
Lennox RT-5 solar cycle trainer or equivalent

IV. Method Performance Conditions

The students, by means of review, are called upon to draw the piping of a baseline system on the blackboard. All mechanical components should be labelled. Flow patterns for basic modes of operation are discussed. The function of all electrical controls are discussed and their interrelationships with overall flow patterns. The slides depict and highlight each of the major modes of operation. The presentation for each mode of operation should include both the mechanical and electrical systems. Trainers are interfaced to vividly display the circuitry that controls solar system operation.

V. Outline

I. Components
- A. Mechanical
  - (1) solar system design
  - (2) modes of operation
    - a. first stage heating from collectors
    - b. first stage heating from storage
    - c. first and second stage heat from collectors and auxiliary heat
    - d. first and second stage heat from storage and auxiliary heat
    - e. second stage only
    - f. storage tank heating
    - g. purging excess heat from system
- B. Electrical
  - (1) operation and function
    - a. differential controller
    - b. purge aquastat
    - c. storage aquastat
    - d. solar coil limit
    - e. thermostat
    - f. plug in relays
  - (2) electrical symbols
    - a. reading schematic wiring diagrams
  - (3) schematic wiring diagrams - logic system
    - a. modes of operation
      1. collectors to storage (no heat demand)
      2. first stage heat demand (from collectors)
      3. first stage heat demand (from storage)
      4. first stage heat demand (auxiliary controlled by W_1)
      5. second stage heat demand
      6. purge cycle

2. Controls - air
- A. Control description
  - (1) modes of operation
- B. Standard controls
  - (1) temperature control sequence of operation
  - (2) schematic
- C. Control panel and electrical power requirements
- D. Standard flow schematic and modes of operation

VI. Student Evaluation Parameters

1. Discuss the operating principles of a centrifugal circulating pump.
2. Discuss the operating principles of an air circulating blower.
3. Describe how the heat exchanger functions.
4. Identify the various electrical control devices used in solar heating systems.
5. Explain the functions of various hydronic specialty items used in the control of air or liquid in a solar assisted heating system.

VII. Sequence of Instruction

1. Read all reference materials.
2. View all slides and overheads of schematics.
3. Work with demonstration system, wiring up all components until all are understood.
4. Take Unit 8 quiz.
5. Take Unit 7 and 8 Examination.

Unit 8 - Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. The word fluid as used in these lessons refers to both liquid and air.

T F 2. Pump sizing is not very critical to the solar heating system.

T F 3. Piping creates little or no resistance to liquid flow.

T F 4. Pump capacity decreases as head pressure increases.

T F 5. Pump specifications cannot be established until flow resistance is calculated.

T F 6. Larger pumps are required in the drain-down system as compared to a closed loop system of camparable size.

T F 7. Pumps rated at 150 psi are recommended for collector loops.

T F 8. One-speed pumps are as effective as two-speed pumps.

T F 9. Conventional furnace blowers may be installed in solar collector systems using air as the fluid.

T F 10. Static pressure is the type of air pressure measured in automobile tires.

T F 11. In low pressure systems, velocity pressure is most often used as a design standard for moving air.

T F 12. A system's performance cannot be predicted before it becomes operational.

T F 13. A thermostat is an actuator.

T F 14. A solenoid valve is an actuator.

T F 15. An outdoor thermostat is never used in conjunction with the collector (fan) circulation system.

T F 16. A differential thermostat measures temperature in more than one place at the same time.

T F 17. Some thermostats operate because of the difference in expansion of two metals.

T F 18. A bellows/diaphragm sensor must be open to the air to allow liquids to expand.

T F 19. A thermistor functions because of an internal change in electrical resistance.

T F 20. Corrosion will not effect the sensitivity of a thermistor.

T F 21. Thermistors are manufactured in various mountings.

T F 22. A transformer may be designed to either step-up or step-down voltage.

T F 23. Collector loops must be filled manually.

Fill in the blanks with the word (or words) which most accurately completes the thought.

24. The primary circuit connects the _____ to the _____

25. Pump capacity is given in _____ per _____

26. To prevent freeze-ups, liquid collector loops are protected by _____ or _____ _____ _____

27. The most common heat exchanger used between collector and storage is called the _____ and _____

28. Three types of pressures that apply to air movement are _____, _____ and _____

29. An air system should operate at a point where the _____ and _____ curves intersect.

30. The two elements of a control system are the _____ and the _____

31. The first stage of a two-stage thermostat calls for heat from the _____ or _____

32. The second stage of a two-stage thermostat calls for heat from the _____ _____ _____

33. The grease-like material to keep thermistors from losing sensitivity is called a _____ _____ _____

34. Thermistors contain a _____ element.

35. Electrically powered valves are called _____ valves.

36. In an air system, an electrically powered _____ functions like the _____ in a liquid system.

37. A relay is a(n)_____switch.

38. The specialty item that keeps a closed liquid system operating between specific pressure limits is the_____ _____

39. Valves that adjust flow rates through the collector array are_____ valves.

40. To reduce corrosion among dissimilar metal piping and components, they are installed by using_____unions.

41. A manual fill system includes a:

    A._____

    B._____

    C._____

42. The fan system curve, or balance point, can be changed by:

    A._____

    B._____

    C._____

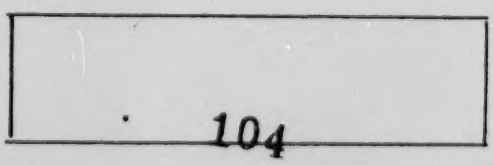
In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

43. Liquid moving pumps operate with a _____:
    a. reciprocating action
    b. syphoning action
    c. pulsating action
    d. centrifugal action

44. One psi of pressure is equal to:
    a. 0.43 feet of water
    b. 1.00 feet of water
    c. 2.32 feet of water
    d. 3.00 feet of water

45. The valve that allows fluid movement in only one direction is a:
    a. check valve
    b. pressure relief valve
    c. balance valve
    d. pressure reducing valve

46. Complete the drawing for a shell and tube heat exchanger.



Unit 7 and 8 Examination

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Although spelled differently, insulation and insolation have the same meaning.

T F 2. The lens of a concentrating collector must remain perpendicular to the rays of the sun.

T F 3. Flat plate collectors are equally efficient any time of the day.

T F 4. Operating temperatures are the same for all types of collectors.

T F 5. A serpentine piping design is used in concentrating collectors.

T F 6. Air spaces between cover plates are sealed from each other.

T F 7. About 95% of the heat that strikes an absorber plate passes into it.

T F 8. Fluid systems refer to either air or liquid being used to transfer heat.

T F 9. Any size blower could be used for the differently designed air collectors.

T F 10. Liquid transfer tubes may only be suspended above or below the absorber plate.

T F 11. "Drain-down" is an alternative to using antifreeze in collector loop.

T F 12. Aluminum is a good material for collector tubing because it can be shaped easily.

T F 13. Metal and fiberglass may be used for collector frames.

T F 14. The reason for needing a storage unit is that solar heat is variable and interruptable.

T F 15. The higher the specific heat of a substance the better it will perform to store heat energy.

T F 16. Water will hold about twice as much as heat as rock for the same volume.

T F 17. Phase change storage can be smaller than water storage for a given BTU capacity.

T F 18. Wax gives off heat when it cools and solidifies.

T F 19. Phase change materials will never be practical.

T F 20. A storage unit cannot be constructed that is considered "too" large.

T F 21. Collector efficiency will be reduced by a storage unit which is too small.

T F 22. A solar heating system must have a heat storage unit.

T F 23. When estimating maximum building heat loss, the average daily temperature is used.

T F 24. Rock will hold heat longer than water.

T F 25. Rocks in a storage unit must be washed periodically if not protected by filters.

T F 26. Standard fiberglass thanks have been proven very servicable even when liquid temperatures approach the boiling point.

T F 27. Glasslined tanks may be the fastest to deteriorate.

T F 28. The basement is the only place that pebble storage can be placed.

T F 29. Blowers are placed in the circuit to take air from storage and move it through the collector.

T F 30. Pressure drop means that fluid flow is being opposed by friction.

T F 31. A "drain down" circuit is always an open loop system.

T F 32. Inhibitors may be added to closed loop circuits.

T F 33. Antifreeze or other special fluid may be added to closed loop circuits.

T F 34. Air systems do not really need to be balanced.

T F 35. Thermistor operation is due to the change in resistance of a wire wound element.

T F 36. A thermistor needs to be mounted within about 10 feet of its controller.

T F 37. Thermistors are fairly standard in design but there are numerous mounting practices.

T F 38. The component in a liquid solar heating system that is furthest from the ground is a float-type air vent.

T F 39. Fill systems can be either manual or automatic.

Fill in the blank(s) with the word (or words) which most accurately completes the thought.

40. Two types of collectors are the _____ and _____

41. The alternatives to primer and black paint on an absorber plate are called _____ surfaces.

42. The most effective liquid collector is the _____ _____ _____

43. Two popular insulating materials for collector frames are _____ and _____ _____

44. Flow rates for an air system will be about _____ to _____ cfm per sq ft of collector.

45. Flow rates for a liquid system will be about _____ to _____ gpm per sq ft of collector.

46. Two ways to contain heat are with the _____ and _____ _____ storage systems.

47. Selecting a storage medium involves its _____ _____ _____ and _____ of the materials.

48. Two disadvantages of a liquid system caused by temperature change are _____ and _____ points.

49. To move fluids, _____ in a liquid system perform the same function as _____ in the air system.

50. To control fluids, _____ in the liquid system perform the same function as _____ in the air system.

51. Two important pressures in duct systems are _____ pressure and _____ pressure.

52. A control device to measure temperature in two locations is a _____ controller.

53. The first of a two stage thermostat calls for heat from the _____ or _____ and the second activates the _____ _____ _____

54. The three commonly used heat sensing devices are _____, _____/_____and_____

55. To prevent overpressurizing in a liquid system a(n)_____ tank is installed.

56. The use of _____valves and_____makes component replacement convenient.

In the following multiple choice questions, choose the phrase which most correctly completes the statement, and circle the corresponding letter in front of the phrase.

57. Transparent covering would be less useful if they could not:
    a. respond to the heat demand of a building
    b. be removed for cleaning
    c. change temperature rapidly

58. The preferred cover plate materials is:
    a. acrylic plastic
    b. low iron glass
    c. high silica glass
    d. not listed above

59. Collectors installed in Minnesota and Louisiana would
    a. be the same
    b. differ in mounted height
    c. have the same tilt angle
    d. require more covers in Minnesota

60. A "blackbody" refers to the:
    a. absorber plate
    b. collector frame
    c. black rubber cover gaskets
    d. heat transfer system

61. Present day selected coatings are:
    a. extremely durable
    b. highly reliable
    c. relatively inexpensive
    d. about as efficient as paint

62. Fins are used in air collectors to:
    a. increase heat transfer
    b. lower internal temperature
    c. restrict air flow
    d. support the absorber plate

63. A collector rated at 60% efficient indicates the:
    a. average daily heat transfer
    b. differences between inlet and outlet temperature
    c. heat transferred at noon for given inlet and ambient conditions
    d. amount of sunlight that strikes the collector in a given time

64. The best estimates of maximum heat contribution that can be economically built into a solar system is:
    a. 40%
    b. 60%
    c. 80%
    d. 100%

65. It is reasonable to build storage units for_____of heat requirement.
    a. one days
    b. two days
    c. five days
    d. ten days
    e. overnight

66. Locations for storage units means using space that is:
    a. the least valuable
    b. closest to the collector
    c. in the center of the building
    d. outside the structure

67. Electrolysis in a liquid system:
    a. increases the efficiency of the collector
    b. inhibits chemical action
    c. reduced the size of the storage unit
    d. causes piping to corrode

68. Normally, rock beds _____feet deep will cause a minimum of air pressure drop.
    a. two
    b. four
    c. eight
    d. ten

69. Closed loop and open loop systems differ because of the
    a. damper and valve system
    b. heat exchanger
    c. heat transfer medium
    d. design of the storage unit

70. A thermal compound is needed with some thermistors to:
    a. adhere them to an absorber
    b. glue them in a well
    c. protect them from air or water
    d. reduce heat loss

71. An electrically controlled valve is a:
    a. solenoid valve
    b. relay
    c. thermostat
    d. check valve

72. An electromagnatic switch is commonly called a:
    a. solenoid
    b. transformer
    c. relay
    d. controller

73. Control devices are used for:
    a. ease of installing the solar heating system
    b. safe and automatic operation
    c. setting manual valves
    d. all of the above purposes

AREA - SOLAR APPLICATION INSTALLATION

Unit 9 - Whole House (Installation Procedures) New and Retrofit

I. Instructional Objective

Unit nine discusses the installation of collectors, heat storage units, control devices, and specialty items. Special emphasis is placed on the scheduling of events in the sequence of activities in constructing the building. SMACNA and other organizations have established standards and guidelines for many of the installation practices used in the construction industry that apply to solar heating.

Specifications and drawings for the structure provide the manufacturer's name and model for different components in the solar heating system, as well as for the rest of the structure. Manufacturers of larger pieces of the heating equipment provide specific data for mounting and adjusting procedures for their products. The installer needs this information as do the designer and builder of the home or business being constructed.

Unit nine provides the learner with information about the sequence of events for installing liquid and air solar assisted heating equipment. These installations are discussed first for new construction and then for retrofitting an existing structure. Topics are presented in the order that they would normally occur in construction scheduling. In addition, the practice of insulating ducts and pipes at the proper time is also presented.

II. Reference Materials

Fundamentals of Solar Heating, Lesson 9
Installation Standards, Solar 5-1 & 7-1 & 8-1
Solar Decision Book, 21
Lennox Solar Volume I Installation
Installation Manual SunCell (Research Products)
Installation Manual SunPride (Revere)
Installation Manual Solaron

III. Visual Aids

Kaidib Films International Slide Series on Active Solar Installation
Lennox Solar I Slides 181-188
Field trips of existing installations and visits to installations in progress

IV. Method Performance Conditions

The students will develop a step by step procedure for installation and then perform an actual installation on a sample application.

V. Outline

I. Installation Barriers
- A. Lack of understanding by potential customers
- B. Institutional constraints (too new)
  - (1) Legal
    - a. zoning
    - b. sun rights
    - c. solar easements
  - (2) Building Codes
    - a. contact local building inspector
  - (3) Financial
    - a. restricted loans due to use of solar
  - (4) Insurance
    - a. no reluctance to insure solar

2. Array mounting variations
- A. On the top of roof
- B. Flush with roof
- C. Raised above roof
- D. Flat roof frame
- E. Ground level
- F. Lean to

3. Installation
- A. Water
  - (1) Installation check list
    - a. panel installation
    - b. protection from freezing
    - c. protection from overheating
    - d. system cleaning and charging
    - e. corrosion inhibiting
    - f. monitoring of system (log sheet)
- B. Air
  - (1) Air panel introduction
    - a. air heating unit
    - b. heat storage unit
      1. residential
      2. commercial

4. Scheduling installations
- A. Gather all material necessary to complete installation
  - (1) residential
  - (2) commercial
- B. Consider location of project and weather
- C. Sample schedule for liquid solar system new house
  - (1) storage tank placement
    - a. permits
    - b. fees
    - c. engineering
    - d. site work
    - e. excavate basement
    - f. trench footings
    - g. pour concrete
    - h. place storage tanks (NOTE: if retrofit tank will have to be welded together in existing basement and sized to fit area).

(2) Collector supports - new house
   a. floor girder
   b. frame floor
   c. subfloor
   d. frame and sheathe exterior walls
   e. set trusses
   f. fabricate collector supports
   g. sheathe roof (NOTE: on existing structure collector supports will have to be designed around present trusses).

(3) Installing collectors and plumbing new house (NOTE: leak test all components before installing on site)
   a. roof felt
   b. place collectors on roof and connect manifold
   c. roof and flashing
   d. storage piping connections
   e. storage leak test filling
   f. piping to equipment area
   g. collector and heat transport piping (pumps, valves, etc.)
   h. heat exchange piping
   i. control temperature sensors installed
   j. total plumbing leak test
      1. storage
      2. piping
      3. collector loop
      4. heat transport
      5. heat exchange
   k. insulate tank
   l. pour basement slab over tank (NOTE: retrofit storage tank will be above slab)

(4) Insulation and auxiliary heating
   a. rough electrical
   b. solar control panel
   c. rough sheet metal
   d. insulate house
   e. insulate solar piping
   f. install auxiliary heating and/or cooling system
   g. dry wall

(5) Preheat coil and control wiring
   a. preheat coil and comestic hot water tank
      1. tie in final plumbing
   b. control electrical
      1. complete wiring of main house control panel in living area
      2. complete all auxiliary and solar electrical tie ins
   c. final inspection and start up of all equipment
   d. explain to owner (operation and maintenance)

5. Sample construction schedule for air solar system new house
   A. Rock bed storage fabrication
      (1) permits
      (2) fees
      (3) engineering
      (4) site work
      (5) excavate basement
      (6) structural base for storage
      (7) trench footings
      (8) pour concrete

(9) fabricate storage container
(10) insulate storage
(11) place temperature sensors
(12) fill storage
(13) floor girders and framing (NOTE: retrofit of storage will be constructed on existing basement floor)

B. Collector supports
(1) frame and sheathe exterior walls
(2) set roof trusses on rafters
(3) fabricate collector supports
(4) sheathe roof
(5) roof felt (NOTE: retrofit - remove shingles in area collectors will cover, mount on existing roof)

C. Install collectors, heat exchanger and controls
(1) place collector on support
(2) install control sensors in collectors
(3) rough plumbing
(4) heat exchanger piping for domestic hot water
(5) rough electrical
(6) install selected solar controls

D. Ductwork - insulation and auxiliary heating and/or cooling
(1) rough sheet metal
(2) collector and heat transport ducts - dampers, blowers, heat exchangers
(3) seal air ductwork airtight (caulk)
(4) leak test ducting
(5) leak test collector loop
(6) house insulation
(7) collector duct insulate and inspect
(8) heat transfer duct insulation and inspect
(9) piping installation and inspection
(10) auxiliary heating installation (NOTE: retrofit will be tied to existing auxiliary system)

E. Preheat tank installation
(1) preheat tank and domestic hot water
(2) finish plumbing
(3) finish electrical
(4) complete all control wiring

F. Finish heating system and final inspection
(1) finish heating system
(2) operate all equipment and do final inspection
(3) explain operation and maintenance to owner

VI. Student Evaluation Parameters

1. Explain architectural problems related to installing solar heating systems.

2. Schedule and install collector arrays.

3. Schedule and install heat storage units.

4. Schedule and install controls and specialty items.

5. Schedule and install insulation

VII. Sequence of Instruction

1. Read all reference materials.
2. View all overheads and slides.
3. Visit sites.
4. Install actual system.
5. Take Unit 9 quiz.

Unit 9 Quiz

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Liquid heat storage units can be put in place any time during construction.

T F 2. The bottom of the storage tank should be on the floor for stability.

T F 3. Collectors must be joined to each other as tightly as possible.

T F 4. Some collectors should be covered after installation so they will not overheat internally before being placed in operation.

T F 5. The reverse return array assembly is the easiest to balance.

T F 6. Centrifugal pumps must have positive water pressure on the intake side.

T F 7. In an open loop system, the heat storage unit must contain antifreeze.

T F 8. The open loop system is frequently installed in locations where subfreezing temperatures are rare.

T F 9. In long pipe runs, expansion must be considered.

T F 10. Short lengths of rubber hose can perform the same function as dielectric unions.

T F 11. Rough-in electrical installation includes locating sensors and thermostats.

T F 12. Rock must be uniform in size for the pebble-bed storage unit.

T F 13. Sensors are installed in air system collectors after they are solidly mounted on the roof.

T F 14. Ducts for air system collector loops are installed in the same manner as conventional furnace ductwork.

T F 15. Ductwork may be insulated inside as well as outside.

T F 16. Ductwork to blower connections are made with flexible connectors.

T F 17. Air filters are more critical in the liquid collector circuit than the air system circuit.

T F 18. An electronic air cleaner should not be placed at the inlet to the auxiliary heat source because of high velocity air movement.

T F 19. The air handling module contains most of the electrical controls for its operation.

T F 20. Insulation for the outside surfaces of air system ductwork is added after leak testing is done.

T F 21. Humidifiers cannot be used with all air solar systems.

T F 22. Relief valves in DHW system are typically rated at 50 psi just as the collectors.

T F 23. The setting for the mixing valve for liquid DHW is 140°F.

T F 24. A collector could be mounted flat on a 4/12 pitch roof but maximum output would be reduced.

T F 25. Pebble-bed storage units can be placed outside the structure.

T F 26. Liquid storage tanks can never be placed outside the structure.

Fill in the blanks with the word (or words) which most accurately completes the thought.

27. The practice of installing a solar heating system in an existing structure is called _____

28. Footing for liquid heat storage tanks are engineered according to the weight of the _____ and _____

29. The preferred collector mounting practice is to mount it to a roof constructed at the proper _____ _____ _____

30. Space must be allowed at the top of collector array for the installation of the _____ _____

31. Piping made of _____ or _____ are used for liquid collector loops.

32. Expansion tanks are sized according to the _____ and the _____ _____ in the system.

33. Aluminum metal strips in a _____ erode away and reduce chemical attack in the rest of the liquid collector loop.

34. The basic steps involved in roofing a solar heated building are:

A. _____

B. _____

C. _____

35. Three possible liquid collectors to collector assembly procedures are:

A._____

B._____

C._____

36. Three possible liquid collector array circuits are:

A._____

B._____

C._____

37. An air handling system module may contain:

A._____

B._____

C._____

D._____

38. Materials to insulate a solar heating system should have:

A._____

B._____

C._____

D._____

E._____

F._____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

39. Tank installation is done before the:
    a. basement floor is poured
    b. floor joists are placed
    c. subfloor is nailed down
    d. basement floor is installed

40. For drainage purposes a minimum pitch in piping is_____per 10 feet.
    a. ¼"
    b. ½"
    c. 1"
    d. 2"

41. An air handling module directs airflow for:
    a. space heating from the collector
    b. space heating from the storage unit
    c. space heating from the auxiliary heat unit
    d. all of the above

42. Four gallons of liquid per minute flowing through a ½" pipe at 422fps will have a pressure drop of_____psi/100 ft. (refer to textbook).
    a. 4.22
    b. 6.36
    c. 6.60
    d. 7.42

43. A 1" pipe at 5.57 fps with a pressure drop of 6.36 psi will flow at _____gpm.
    a. 4
    b. 8
    c. 15
    d. 25

AREA - SOLAR APPLICATION INSTALLATION

Unit 10 - Service Hot Water

I. Instructional Objectives
Step by step process to follow for installation of service hot water systems and storage (See Unit 9, same, but for DHW).

II. Reference Materials
Installation Guidelines for Solar DHW Systems
Solar Electric Hot Water Heaters (A.O. Smith)
Solar Energy Domestic Hot water System-Revere
Fundamental of Solar Heating, Lesson 8
Lennox Solar 1, Domestic Hot Water
Installations Standards Solar 19-1

III. Visual Aids
1. Overheads made from different manufacturers installation manuals.
2. Lennox Video Presentation - installation of a domestic hot water system.

IV. Method Performance Conditions
Student, by means of review, will go through roof and ground mounting procedures, installation checklist, installation tool kit.

Student will then do an entire DHW installation and evaluate the job after completion.

V. Outline
1. List of materials normally supplied by manufacturer
   A. Collector
      (1) center
      (2) right
      (3) left
      (4) trim package
   B. Blower assembly - hot water coil controls and mounting accessories
   C. Water pump
   D. Storage tank sensor
2. List of material not supplied
   A. Wood support structure/framing for installation
   B. Miscellaneous nails and screws
   C. Insulation for perimeter flashing
   D. Silicone caulk

E. Mineral spirits

F. Ductwork and accessories
   (1) flexible insulated duct
   (2) riser duct
   (3) flow adjusting dampers

G. Plumbing
   (1) storage tank
   (2) auxiliary hot water heater
   (3) 3/4" piping and fittings
   (4) swig. check valve
   (5) bleeder valve
   (6) temperature pressure relief valves
   (7) pipe insulation

H. Electrical
   (1) low voltage wire
   (2) live voltage wire

3. Tools needed and equipment

A. Conventional construction and HVAC installation tools
   (1) ¼ or 3/8 variable speed reversible drill
   (2) power saw
   (3) extension cords
   (4) scratch awl
   (5) screwdriver
   (6) hoisting harness
   (7) ladders
   (8) crane
   (9) square
   (10) chalk line
   (11) level
   (12) knife
   (13) hammer and nails
   (14) leather gloves
   (15) polarizing sunglasses
   (16) hard hat
   (17) left and right snips
   (18) hand seamers
   (19) scribe
   (20) caulk gun

4. Location of collector

A. Orientation - as close to true south as possible
   (1) compass may not give true south

B. Tilt
   (1) domestic hot water tilt is equal to latitude of region
   (2) snow cover should be considered

C. Shading factor
   (1) check for other buildings shade
   (2) trees

D. No obstruction behind collectors

5. Installation between rafters

   A. Normally done on new construction
      (1) set rafting
      (2) insert first collector, lower left corner
      (3) secure collector
      (4) fasten remaining collectors
      (5) attach sheathing around perimeter
      (6) form and install flashing (sheet metal)
      (7) seal entire collector array

6. Installation on existing roof sheating

   A. Normally done on retrofit applications
      (1) lay out array and placement of duct openings.
      (2) roofing shingles must be removed in area under collectors
      (3) cut holes in roof for duct opening
      (4) make certain duct opening is not over rafter
      (5) fabricate starter strip bottom and left side framework
      (6) install first collector lower left hand corner
      (7) fasten collector
      (8) fasten remaining collectors
      (9) top and right side perimeter framework install
      (10) form and install flashing
      (11) seal entire collector array

7. Separate support structure

   A. Same as between rafters, but frame structure must be built

8. Sealing collector array

   A. Install foam type and caulk
   B. Install trim strips
   C. Install interim trim strips (two collector high array)
   D. Perimeter trim strips
   E. Cover plate

9. Installation of duct work

   A. Manifolds and riser ducts
      (1) manifold velocity not to exceed 600 fpm
      (2) 2" insulation
      (3) silicone airtight seals
   B. Collar installation to collector and manifold
      (1) seal with silicone
   C. Sensor installation
      (1) drill hold in base of collar on uppermost center outlet opening
   D. Flexible duct connections
      (1) use manufacturers recommended flex duct only
      (2) double band and use tensioning tool

10. Installation and wiring of blower assembly

    A. Mount unit (cannot be in freezing atmosphere)

11. Storage equipment and plumbing

    A. Storage tank
       (1) 20 gallon per collector

    B. Auxiliary water heat
       (1) sized according to HUD

    C. Sensor
       (1) install in tee in lower side

    D. Plumbing
       (1) in accordance with manufacturers recommendation

VI. Student Evaluation Parameters

By completion of the installation of total DHW system (critique of quality of job demonstration).

VII. Sequence of Instruction

1. Read all reference materials.
2. View overhead and videos.
3. Install DHW system.
4. Evaluate and critique job.

AREA - SOLAR APPLICATION INSTALLATION

Unit 11 - Servicing Solar Installations

I. Instructional Objective

Unit 11 deals with the topic of servicing solar assisted heating systems. The information relates to servicing the system after equipment has been installed. Prior to this time, there may have been some testing and inspecting done during rough-in activities.

The system must first be serviced for start-up. This means that the system must be filled with water (or air), and controls must be checked to see that they operate the system properly. A check list must be completed and given to the owner that provides the properly balanced system's operating conditions. Checklists are prepared for both the liquid and the air systems as well as DHW.

Instructions are also provided for period maintenance. This is information that should be given to the owner.

There is also a need to understand troubleshooting practices for use in an emergency.

II. Reference Materials
Fundamentals of Solar Heating, Lesson Ten
Lennox Solar I Maintenance and Troubleshooting
Installation Guidelines for Solar DHW Systems 77 Maintenance
Solaron Solar Energy Systems, 600

III. Visual Aids
Use of actual operating systems
Lennox Trainer ST17 or equivalent

IV. Method Performance Objectives
Problems will be built into systems. Student will be required to follow specific maintenance and troubleshooting procedures to correct system.

V. Outline

1. Installation and maintenance checklist, air and water
2. Panel glass installation and sealing
3. Maintenance protection from freezing
4. Maintenance protection from overheating
5. System cleaning and charging

6. Corrosion Inhibiting

7. Monitoring of system and log sheet

VI. Student Evaluation Parameters

1. Discuss the general information necessary for start-up.

2. Perform the operations necessary to start-up a liquid system.

3. Perform the operations necessary to start-up an air system.

4. Identify the periodic maintenance procedures for various components of the solar heating system.

5. Explain the troubleshooting procedures for a system that needs emergency servicing.

6. Discuss maintenance problems that are common among solar heating systems.

7. Describe the purpose and extent of warranties.

VII. Sequence of Instruction

1. Read all reference materials.

2. Work with trainers and systems until maintenance and troubleshooting procedures are firmly established.

3. Take Unit 11 quiz.

4. Take Units 9, 10 and 11 Examination.

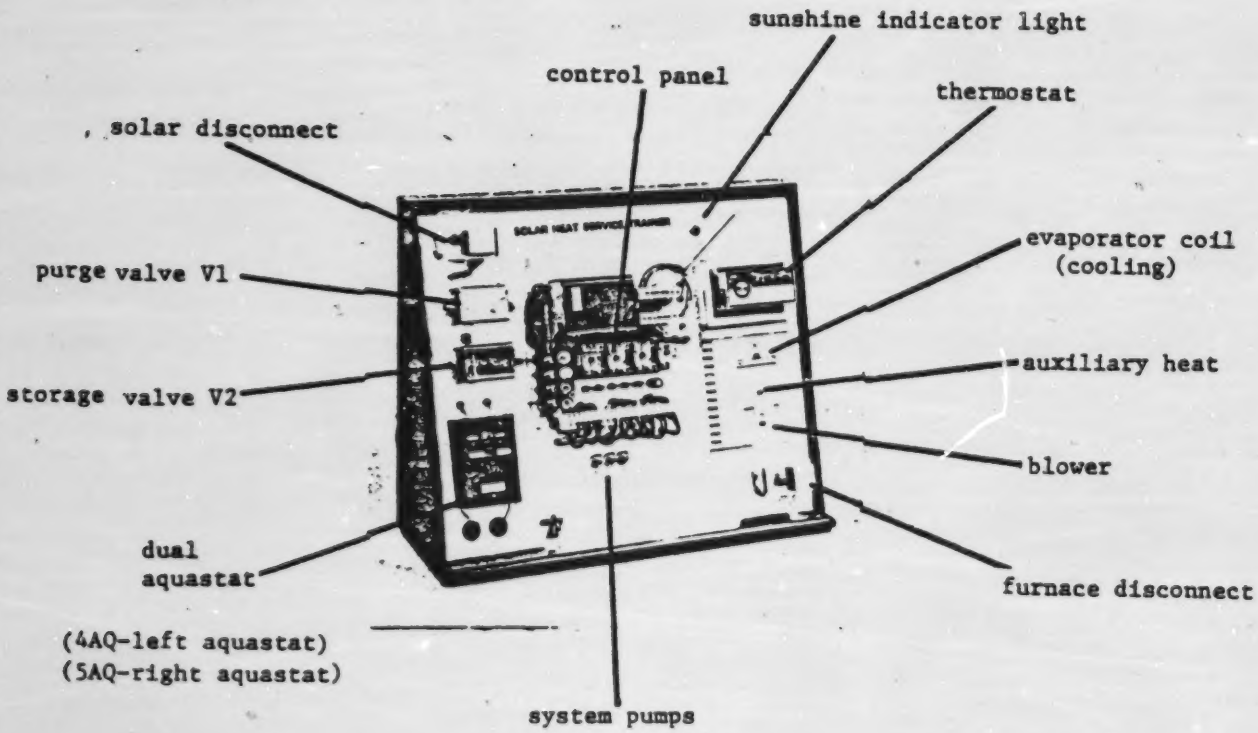
Available Lennox Corporation.

ST-17 SOLAR HEAT SERVICE TRAINER

INTRODUCTION

The ST-17 trainer is designed to teach normal operation and trouble-shooting of the electrical system for a typical solar installation. This typical solar installation has space heating and domestic hot water heating capabilities and is a 3-pump, 2-valve hydronic system (see Lennox Solar Manual for additional information on the typical solar system).

PARTS IDENTIFICATION



Unit 11 Quiz

Please indicate whether the following statements are true or false by crawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. Safe procedures are important in servicing a solar heating system.

T F 2. Collectors may reach temperatures well above the boiling point of water.

T F 3. A good designer will prescribe the precise location for every element of the system.

T F 4. Start-up begins after components are in place, leak tests are completed and electrical controls are installed.

T F 5. It is almost impossible to totally purge air from a liquid system at start-up.

T F 6. Capping drain valves after start-up will prevent accidental drain down.

T F 7. Controllers operate as a result of the electrical current flow through the sensors.

T F 8. The system installer should complete a checklist and give it to the customer.

T F 9. Instruments to balance a solar heating system must be calibrated regularly.

T F 10. Absorber panels are anodized and not subject to shipping or peeling.

T F 11. Duct leaks should be located before building is closed in.

T F 12. Sensors typically cannot be repaired in the field.

T F 13. Most electronic controls will have to be adjusted at the time of start-up.

T F 14. Some heat transfer fluids may deteriorate seals and gaskets.

T F 15. Manufacturers generally guarantee the efficiency of their solar equipment.

T F 16. Manufacturers are likely to guarantee solar heating systems if they manufacture all components and certify to the training of installers.

T F 17. Poor packaging and shipping practices are a major cause of system malfunction.

T F 18. There are more problems with low pressure systems than there are with high pressure systems.

Fill in the blanks with the word (or words) which most accurately completes the thought.

19. The two most prevalent servicing hazards are _____ and _____

20. Low voltage circuits of _____ volts is used for _____ _____ and _____

21. To insure that all air is removed from a liquid system at start-up the service man must _____ each day for several days of operation.

22. Equalizing the temperature at the top of a liquid collector array is done by an adjustment of a _____ at the top of the collector.

23. Sensor accuracy is affected by a _____ or lack of _____

24. Organized _____ _____ are essential to a systematic approach to balancing.

25. Clogged collector weep holes cause a _____ _____

26. Depositing a film on the inside of the collector from vaporizing materials is called _____

27. A limited warranty is free of defects in _____ and _____

28. Glycol in a collector loop should be about _____ % concentration.

29. Aluminum collectors will corrode rapidly unless a _____ is installed.

30. Fiberglass tanks must be rated for at least _____ ^{o}F.

31. Start-up involves:

A. _____

B. _____

C. _____

32. Periodic maintenance involves checking:

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

33. An air handler contains:

A. _____

B. _____

C. _____

D. _____

E. _____

34. If a motor fails to operate, the electronic control should be replaced only after completing four troubleshooting activities which are to:

A. _____

B. _____

C. _____

D. _____

35. The basic approach to troubleshooting is to:

A. _____

B. _____

C. _____

D. _____

36. Four main categories of system failure are:

A. _____

B. _____

C. _____

D. _____

37. The following list is typical of the tools needed to balance an air system.

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

G. _____

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

38. "Out of adjustment" complaints result when the:
    a. heating capacity seems to be decreasing
    b. heating is uneven and drafty
    c. operating cost is increasing
    d. noise level is rising
    e. all of the above

39. Of the following, which does not affect the efficiency of a collector?
    a. condensation
    b. leakage
    c. dust
    d. cracked rubber mounts

40. The periodic maintenance of an air handler requires:
    a. damper adjustment
    b. testing concentration of antifreeze
    c. adjusting balance dampers
    d. lubrication

Unit 9, 10 and 11 Examination

Please indicate whether the following statements are true or false by drawing a circle around T (to indicate TRUE) or F (to indicate FALSE).

T F 1. It is not necessary to install a 100% auxiliary heat system.

T F 2. Retrofit is the practice of installing a solar heating system in an existing building.

T F 3. Heat storage units can be installed any place on a concrete slab basement floor.

T F 4. Glass lined steel tanks are virtually trouble-free.

T F 5. Since collectors are light weight, little truss and rafter reinforcement is needed.

T F 6. The fewer number of pipe fittings used, the lower the pressure drop.

T F 7. Roofing is applied after direct mounted collectors have been installed.

T F 8. Liquid collectors are usually placed with the outlet and inlet connectors at the top and bottom respectively.

T F 9. Collector panels must be thoroughly inspected before being hoisted into place.

T F 10. Expansion and contraction is not a problem of securely mounted collector panels.

T F 11. Solar systems may require larger expansion tanks than conventional water filled hydronic systems.

T F 12. If rubber hose is used in a liquid system it must withstand 150 psi.

T F 13. A getter column reduces corrosion.

T F 14. Sensors should be in place before rough-in electrical work is done.

T F 15. Leak testing a system is done before drywall is hung.

T F 16. Control panels can easily be located in cabinets or closets.

T F 17. Rough-in electrical work precedes weatherization.

T F 18. A pebble-bed does not require as much insulation as a liquid storage tank.

T F 19. When planning a collector array, it's good practice to leave room for adding more collectors in the future.

T F 20. Air filters are less important in an all-air solar system.

T F 21. Tight fitting dampers are crucial to the performance of all air systems.

T F 22. Wood frame construction cannot be used to erect a pebble-bed storage container.

T F 23. Standard sheet metal installation practices are not appropriate for solar duct work.

T F 24. Ducts may be insulated internally or externally.

T F 25. There is no danger of freeze up in an air collector solar domestic water heater.

T F 26. A closed loop DHW system may use 30 psi rated relief valve in collector loop.

T F 27. All DHW systems use 125 psi rated temperature/pressure relief valves.

T F 28. The area below a garage floor can be used for heat storage units.

T F 29. The more that fiberglass insulation is compressed, the more effective it becomes.

T F 30. Under certain conditions collectors can reach temperatures of 300°F.

T F 31. Some air remains in suspension in a liquid system and cannot be vented until the fluid is heated.

T F 32. The installer must design a different kind of sensor mount to be used in each specific location.

T F 33. Shorting out a sensor will simulate an extremely cold condition.

T F 34. Disconnecting the collector sensor from the control simulates an extremely cold condition.

T F 35. Overloading is a common cause of failure in electrical equipment.

T F 36. Outgassing is the depositing of an oily or powdery film on a cover plate.

T F 37. A limited warranty means the product is free from defects in material and craftsmanship.

T F 38. Solar heating systems conform easily to the Home Owners Warranty plan available when a home is sold.

T F 39. All equipment should be labeled if it is hazardous.

T F 40. Plugged weep holes are a problem with ductwork.

T F 41. Solar heating systems are hazard-free.

T F 42. Very few communities have legislated special coding for solar heated building construction.

T F 43. Some states have passed "Right to Light" laws.

T F 44. Some standards have been developed for solar heating systems by the federal government.

T F 45. Building inspectors should be contacted before construction begins.

T F 46. Local jurisdictional problems may exist when solar systems construction contracts are negotiated.

T F 47. All money lending agencies consider solar heating systems to be an asset to the property.

T F 48. Collectors are considered high risk factors for comprehensive insurance.

T F 49. An installer should give all warranties and product information to the owner after the system is in operation.

Fill in the blanks with the word (or words) which most accurately completes the thought.

50. Footings must be sufficient to place liquid storage tanks_____ above the basement floor.

51. Rough-in electrical work includes running electrical service to the _____and wire to the_____

52. Rock storage units are generally constructed of_____, _____, or_____

53. Rough-in ductwork begins_____ _____ _____

54. Electrical service of_____V and_____V are required at the control panel but this is transformed to_____V for most control circuits.

55. Liquid DHW circuits are classified as_____loop or _____systems.

56. Minimum thickness of insulation for storage tanks should be_____ inches, and for pipes and ducts, it should be_____inches.

57. Start-up of a liquid system involves_____the system, testing_____and measuring_____

58. Anemometers, tachometers, and manometers would be needed to balance a (an)_____solar heating system.

59. A proportional control is needed for_____ _____ fans and pumps.

60. Right to light problems arise from interference from_____ and_____

61. Some examples of tax breaks as incentives to invest in solar heating are_____ _____and_____taxes.

In the following multiple choice questions, choose the phrase which most correctly completes the statement and circle the corresponding letter in front of the phrase.

62. The roof pitch for direct mounted heating only collectors on building at 30° latitude would be:
    a. 6/12 or 26½°
    b. 7/12 or 30°
    c. 12/12 or 45°
    d. 4/12 or 18½°

63. Collector sensors should be installed
    a. before inspection
    b. before hoisting the collector to the roof
    c. after hoisting the collector to the roof
    d. when installing electrical circuits

64. To drain properly, horizontal piping must have_____pitch for each 10 feet of run.
    a. ¼ inch
    b. ½ inch
    c. 1 inch
    d. 2 inches

65. Insulation requirements are engineered to:
    a. counteract heat loss
    b. fill the walls
    c. cover the foundation
    d. cover the ceiling joists

66. Much of the responsibility for equipment placement is delegated to the:
    a. architect
    b. designer
    c. installer
    d. owner

67. If a system is not performing properly major changes to the system should be made only after
    a. redesigning the system
    b. heat losses are reduced
    c. adding tubing to the collector
    d. using larger rocks in the pebble-bed

68. To insure air removal, at start-up of liquid system, the serviceman should:
    a. open all float vents
    b. loosen the collector connector
    c. check the system after a week's operation
    d. systematically open all bleeder valves

69. Sensors function because:
    a. water or air pass over them
    b. of the kind of controller used with them
    c. heat changes in their electrical resistance
    d. of reasons not listed

70. To balance an air solar heating system, servicepersons do not need to
    a. review the shop drawings
    b. obtain pump performance data
    c. adjust dampers
    d. have manufacturer's recommendations

71. The most difficult liquid storage tanks to seal are:
    a. concrete
    b. fiberglass
    c. glass-lined
    d. galvanized steel

72. Checking the getter column often involves
    a. adding lubricants
    b. changing aluminum strips
    c. cleaning the bowl
    d. adjusting the flow rate

73. A system may be out of adjustment if:
    a. its ability to heat is decreasing
    b. the heat is uneven
    c. operating costs rise
    d. all of the above occur

74. To keep from contaminating potable water, a solar system needs
    a. a pressure relief valve
    b. a back-flow check valve
    c. a balancing valve
    d. a shut-off valve

AREA - HVACS (HEATING, VENTILATING, AIR CONDITIONING, SOLAR) ELECTRICAL

Unit 12 - Basic Electrical

I. Instructional Objective

Student will be acquainted with fundamentals of electrical concepts essential to understanding the function and application of electric motor, pump, circuits, transformers, etc. Student will learn practical application of basic electricity as it applies to servicing and installation of heating, air conditioning, refrigeration, and solar equipment.

II. Reference Materials

Basic Electricity - Honeywell 1-7
Electricity for Heating, Air Conditioning, Refrigeration, 1, 2, 4, 5, 6
Electric Circuit Fundamentals-Lurch
Handbook of Simplified Electrical Wiring Design, Lenk
Carrier GTE Series 1, 2, 4, 5, 6 Applied Electricity
Lennox Phase 1(5) Basic Electricity
SAMS 20932 Basic Electricity

III. Visual Aids

Carrier GTE Series Applied Electricity
Slides: Sections 1, 2, 4, 5, 6
Honeywell: Overheads - Motors and Basic Electricity

IV. Performance Conditions

Given electrical test boards with transformers and light bulbs and switches, all different types of electrical motors and their components.

V. Outline

1. Electron Theory; D-C Current Flow; Sources of D-C; Conductors and Insulators: Classificaton of Electricity; Safety
2. Ohms Law; Series Circuits; Parallel Circuits; Compound Circuits; Power.
3. Magnets; Magnetic Fields; Generator Principles: Transformer Principles; Relays
4. A-C Circuits; Inductance; Capacitance; Reactance; Current, Voltage, and Power in an A-C Circuit.
5. Review; Schematic Symbols; Introduction to Motors
6. D-C Motors; D-C Generators; A-C Generators Polyphase Motors

7. Shaded Pole, Split Phase; Capacitor Start Induction Run, and Permanent Split Capacitor Motors

8. The Ammeter; The Voltmeter; The Ohmeter; Multimeters; Theory of Operation and Use

9. Fundamental Heating, Cooling and Refrigeration Control Circuits

10. Electrical Piping; General Wiring Practice; Distribution Systems; Fuses; Conductor Sizing; Codes

VI. Student Evaluation Parameters

Student will learn basic ohms law and apply it. Know series parallel circuits and wire same. Transformer theory and practice. Student should identify and work with all types of motors and their starting components. Student, by end of this unit should thoroughly understand all basic electrical used in the HVAC industry.

VII. Sequence of Instruction

1. Read all assigned reference materials.

2. View all visual aids.

3. Discuss electron theory and Sine wave, ohms law, etc, with students.

4. Work out lab projects.

5. Have outside speakers on these instruments.

6. Take Unit tests.

AIR CONDITIONING AND REFRIGERATION - EXAMPLE LAB PROJECT

Objective:
To become familiar with the methods used in checking the Micro Farrad ratings of capacitors.

Materials Needed:
Test Cord
Screw driver or Bleed Off Resistor
Two Run Capacitors
Two Start Capacitors
Watt Meter

Procedure:
1. Record voltage at wall outlet.

2. Record current draw of the capacitor. (see handout)

3. Place the volt reading and the current reading into the formula to find:

   M.F.D.

   $$M.F.D. = \frac{2650 \times Amps}{volts}$$

   Do test with four capacitor

Precautions:
Discharge capacitor after each test. It will store a high charge.

Do not apply voltage to start capacitor for longer than two seconds.

If capacitor is warm, let it cool prior to applying voltage.

Lay capacitor down when doing tests.

Take all precautions you feel necessary.

Ask if you are in doubt.

SAFETY GLASSES MUST BE WORN.

Turn in your work sheets before leaving the lab.

Unit 12 - Quiz 1

MULTIPLE CHOICE: PICK THE CORRECT ANSWER.

1. THE SMALLEST PARTICLE INTO WHICH A SUBSTANCE, SUCH AS WATER, CAN BE DIVIDED IS KNOWN AS A/AN:
   A. ATOM
   B. MOLECULE
   C. NUCLEUS
   D. ELECTRON

2. WHAT HAPPENS TO AN ATOM WHEN IT LOSES SOME ELECTRONS?
   A. IT BECOMES POSITIVELY CHARGED
   B. IT BECOMES NEGATIVELY CHARGED
   C. IT BECOMES ELECTRICALLY NEUTRAL
   D. IT CHANGES TO A NEGATIVE ION

3. WHICH OF THE FOLLOWING IS USED TO EXPRESS THE ELECTRICAL PRESSURE THAT CAUSES CURRENT TO FLOW?
   A. FREE ELECTRONS
   B. RATE OF FLOW
   C. DYNAMIC ELECTRICITY
   D. ELECTROMOTIVE FORCE

4. IN ORDER FOR A CURRENT TO FLOW, YOU MUST HAVE A COMPLETE ELECTRICAL:
   A. RELAY SYSTEM
   B. CIRCUIT BREAKER
   C. CIRCUIT
   D. GENERATOR

5. ELECTRONS ARE NEGATIVELY CHARGED AND THEY:
   A. ATTRACT EACH OTHER
   B. REPEL EACH OTHER
   C. REPEL POSITIVELY CHARGED PROTONS
   D. ATTRACT NEGATIVELY CHARGED PROTONS

6. THE ELECTRICAL EFFECT WHICH ACCOUNTS FOR THE OPERATION OF ELECTRICAL MOTORS IS THE:
   A. HEAT EFFECT
   B. STATIC EFFECT
   C. MAGNETIC EFFECT
   D. RADIATION EFFECT

T OR F 7. OHMS LAW STATES THAT IF WE APPLY A POTENTIAL OF 1 VOLT ACROSS A RESISTANCE OF 1 OHM, A CURRENT OF 1 AMPERE WILL FLOW THROUGH THE RESISTANCE.

T OR F 8. FOR SIMPLICITY'S SAKE; ALL THE ELECTRICAL WIRING DIAGRAM SYMBOLS USED IN THIS INDUSTRY ARE STANDARD.

T OR F 9. ELECTRICITY IS MOVING ELECTRONS.

T OR F 10. A HIGH VOLTAGE NUMBER INDICATES THE POTENTIAL TO DO A LOT OF ELECTRICAL WORK.

T OR F 11. ELECTRICAL POTENTIAL IS A GOOD DEFINITION OF THE TERM VOLTAGE.

T OR F 12. SOME KNOWLEDGE IN ALMOST ALL PHASES OF ELECTRICITY IS REQUIRED IN THE REFRIGERATION AND AIR CONDITIONING INDUSTRY.

T OR F 13. THE WIRING DIAGRAM LEGEND IS INTENDED TO AID THE SERVICEMAN'S MEMORY.

T OR F 14. MOST ELECTRICAL SERVICE ON AIR CONDITIONING CAN BE DONE WITHOUT BEING ABLE TO READ A WIRING DIAGRAM.

T OR F 15. MOVING ELECTRONS ARE CURRENT.

T OR F 16. RESISTANCE CONTROLS ELECTRON FLOW BY CONVERTING IT TO OTHER FORMS OF ENERGY.

T OR F 17. RESISTANCE CAN BE USED TO CONTROL THE FLOW OF ELECTRONS.

T OR F 18. ALL MATTER HAS WEIGHT AND OCCUPIES SPACE.

T OR F 19. MATTER CAN BE A SOLID, LIQUID OR GAS.

T OR F 20. ALL ATOMS CONTAIN ELECTRONS AND PROTONS.

T OR F 21. ELECTRONS ARE MUCH HEAVIER THAN PROTONS.

T OR F 22. THE NUCLEUS OF AN ATOM CONTAINS PROTONS AND ELECTRONS.

23. WHEN AN ATOM HAS AN EXCESS OF ELECTRONS IT IS CALLED A:
   A. NEUTRAL ATOM
   B. POSITIVE ION
   C. NEGATIVE ION

24. IN AN ATOM:
   A. THE PROTON ORBITS THE NUCLEUS
   B. THE ELECTRON ORBITS THE NUCLEUS
   C. THE NEUTRON ORBITS THE NUCLEUS

25. ACCORDING TO THE LAW OF CHARGED PARTICLES, UNLIKE CHARGES:
   A. REPEL EACH OTHER
   B. ATTRACT EACH OTHER
   C. HAVE NO EFFECT ON EACH OTHER

26. THE BASIC UNIT OF MEASUREMENT FOR ELECTRICITY IS THE:
   A. GALLON
   B. COULOMB
   C. VOLT

27. THE MEASURE OF COULOMBS PER SECOND IS BETTER KNOWN AS:
    A. AN OHM
    B. A VOLT
    C. AN AMPERE

28. WHEN THERE IS AN ELECTRICAL PATH BETWEEN THE NEGATIVE AND POSITIVE TERMINALS OF A BATTERY, ELECTRONS WILL FLOW THROUGH THE CIRCUIT:
    A. FROM NEGATIVE TO POSITIVE TERMINAL
    B. FROM POSITIVE TO NEGATIVE TERMINAL
    C. BACK AND FORTH

29. THE UNIT OF MEASUREMENT FOR VOLTAGE OR POTENTIAL DIFFERENCE IS THE:
    A. AMPERE
    B. VOLT
    C. OHM

30. OPPOSITION TO THE MOVEMENT OF ELECTRONS THROUGH A MATERIAL IS CALLED:
    A. VOLTAGE
    B. CURRENT
    C. RESISTANCE

31. AN EXAMPLE OF A MATERIAL THAT OFFERS CONSIDERABLE OPPOSITION TO CURRENT FLOW AND IS KNOWN AS AN INSULATOR IS:
    A. COPPER
    B. PORCELAIN
    C. GERMANIUM

31. THE GREEK LETTER OMEGA (Ω) IS THE ABBREVIATION FOR:
    A. VOLT
    B. OHM
    C. AMPERE

32. THE SYMBOL USED TO IDENTIFY RESISTANCE IS:
    A. E
    B. I
    C. R

33. WHAT IS THE CURRENT FLOW IN AMPERES, IF 2 COULOMBS MOVE PAST A POINT IN 0.5 SECONDS?
    A. 1 AMPERE
    B. 2 AMPERES
    C. 4 AMPERES

34. THE JOULE IS THE BASIC UNIT OF MEASURE FOR:
    A. ELECTROMOTIVE FORCE
    B. ELECTRICAL ENERGY
    C. POTENTIAL ENERGY

35. VOLTAGE IS EXPRESSED AS:
    A. JOULES/COULOMB
    B. COULOMBS/SEC.
    C. VOLTS/AMPERES

36. THE NUMBER OF FREE ELECTRONS THAT ARE IN A MATERIAL DETERMINES ITS RESISTANCE. IF A MATERIAL HAS MANY FREE ELECTRONS, IT WILL HAVE:
    A. LOW RESISTANCE
    B. HIGH RESISTANCE
    C. NO RESISTANCE

37. TO OPERATE A BIG COMPRESSOR WE WILL NEED A _____ OR _____ NUMBER OF ELECTRONS?
    A. LARGE
    B. SMALL

38. OHMS LAW IS USUALLY WRITTEN IN THIS FORM:
    A. I=E/R
    B. L=Q/Y
    C. M=R/I
    D. R=M/O

39. THE ELECTRICAL TERM INTENSITY OR LETTER "I" STANDS FOR:
    A. LIGHT
    B. ENERGY
    C. AMPERES
    D. VOLTAGE

40. THE TERM ELECTROMOTIVE FORCE IS COMMONLY CALLED IN OUR FIELD:
    A. AMPERE
    B. RESISTANCE
    C. MAGNETISM
    D. VOLTAGE

41. THE LETTER USED FOR OHMS IN THE FORMULA IS:
    A. R
    B. L
    C. Y
    D. E

42. THE TOTAL RESISTANCE OF A SERIES CIRCUIT IS FOUND BY _____ THE SEPARATE RESISTANCES.
    A. SUBTRACTING
    B. ADDING
    C. MULTIPLYING
    D. DIVIDING

43. IN A SERIES CIRCUIT THE CURRENT IS _____ THROUGH ALL PARTS OF THE CIRCUIT.
    A. INCREASING AND DECREASING
    B. INCREASING
    C. SAME
    D. DECREASING

Unit 12 - Quiz 2

Name _____ 108

I. Directions: Mark each of the following statements T (true) or F (false):

1. ____a. All matter has weight and occupies space.
____b. Matter can be a solid, liquid or gas.
____c. All atoms contain electrons and protons.
____d. Electrons are much heavier than protons.
____e. The nucleus of an atom contains protons and electrons.

II. Directions: Match the following:

2.

____a.	-	1. neutron
____b.	+	2. proton
____c.	no sign	3. electron

3.

____a.	A	1. current flow
____b.	C	2. amperes
____c.	I	3. Coulombs
____d.	V	4. Voltage
____e.	E	5. Volt

4.

____a.	1.5 volts	1. battery
____b.	6 volts	2. flashlight cell
____c.	110 volts	3. house voltage
		4. new automotive battery

III. Directions: Select one of the three choices that best completes the statement or answers the question. Place an "X" in the space provided.

5. When an atom has an excess of electrons it is called a:
____a. neutral atom
____b. positive ion
____c. negative ion

6. In an atom:
____a. the proton orbits the nucleus
____b. the electron orbits the nucleus
____c. the neutron orbits the nucleus

7. According to the law of charged particles, unlike charges:
____a. repel each other
____b. attract each other
____c. have no effect on each other

8. The basic unit of measurement for electricity is the:
____a. gallon
____b. coulomb
____c. volt

9. The measure of coulombs per second is better known as:
____a. an ohm
____b. a volt
____c. an ampere

10. When there is an electrical path between the negative and positive terminals of a battery, electrons will flow through the circuit:
    ____a. from negative to positive terminal
    ____b. from positive to negative terminal
    ____c. back and forth

11. The unit of measurement for voltage or Potential difference is the:
    ____a. ampere
    ____b. volt
    ____c. ohm

12. Opposition to the movement of electrons through a material is called:
    ____a. voltage
    ____b. current
    ____c. resistance

13. An example of a material that offers little opposition to current flow and is a good conductor of electricity is:
    ____a. copper
    ____b. porcelain
    ____c. germanium

14. An example of a material that offers considerable opposition to current flow and is known as an insulator is:
    ____a. copper
    ____b. porcelain
    ____c. germanium

15. The Greek letter omega (Ω) is the abbreviation for:
    ____a. volt
    ____b. ohm
    ____c. ampere

16. The symbol used to identify resistance is:
    ____a. E
    ____b. I
    ____c. R

17. What is the current flow in amperes, if 2 coulombs move past a point in 0.5 seconds?
    ____a. 1 ampere
    ____b. 2 amperes
    ____c. 4 amperes

18. The joule is the basic unit of measure for:
    ____a. electromotive force
    ____b. electrical energy
    ____c. potential energy

19. Voltage is expressed as:
    ____a. joules/coulomb
    ____b. coulombs/sec.
    ____c. volts/amperes

20. The number of free electrons that are in a material determines its resistance. If a material has many free electrons, it will have:
    ____a. low resistance
    ____b. high resistance
    ____c. no resistance

Name _____

1. What is the name of the atomic particle that responds to E.M.F. and magnetic forces? _____
2. What charge does this particle have? _____
3. In what direction does this particle move? _____ _____ to _____
4. The measurement unit for potential is _____
5. The measurement unit for current is the _____
6. The measurement unit for power is the _____
7. One horsepower equals _____
8. In electrostatics and magnetism like charges _____ each other.
9. In electrostatics and magnetism unlike charges _____ each other.
10. The insulator between capacitor plates is called a _____
11. - 12. Give 2 of 3 factors that govern capacity of capacitors. _____ and _____
13. - 20. Define these abbreviations:

E.M.F. _____

I _____

R _____

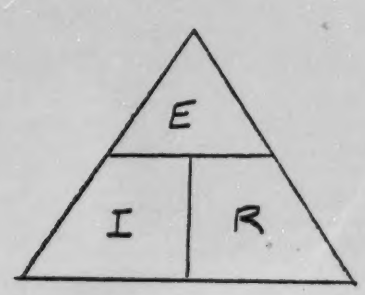
P _____

A _____

W _____

V _____

KW _____



Using Ohm's Law: solve for the unknown:

21.	I - ?	R = 20	E = 100	_____
22.	I - 4	R = 12	E = ?	_____
23.	I = 5	R = ?	E = 150	_____

24. Draw a series circuit with 4 resistors.

25. Draw a parallel circuit with 4 resistors.

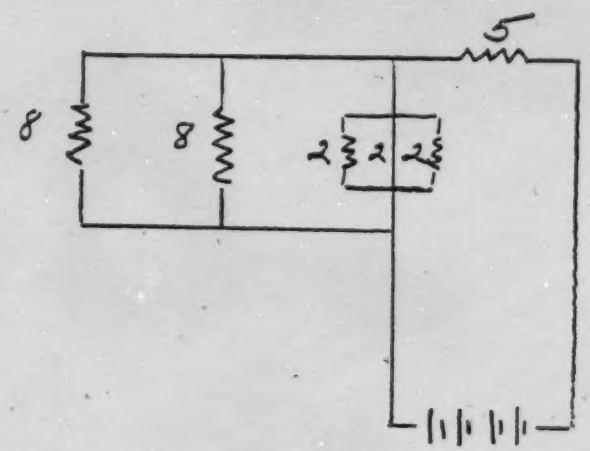
26. Connect 6 dry cells for maximum voltage and list the voltage.

27. Connect 5 lead acid wet cells for maximum amp hrs. List the voltage.

28. When a conductor cuts through a magnetic field or flux, what effect is caused in the conductor?

29. The iron core of an electromagnet will_____ the magnetic force.

30. - 35. Calculate the resistances:
Show work.



$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3$$

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

List the voltage readings in these power systems.

230 VAC 1 Ø

_____ L 1.

_ _ _ _ _ _ _ _ _ _ _ _ N

_____ L 2.

230 VAC 3 Ø

_____ L 1.

_____ L 2.

_____ L 3.

_ _ _ _ _ _ _ _ _ _ _ _ N

208 VAC 3 Ø

_____ L 1.

_____ L 2.

_____ L 3.

_ _ _ _ _ _ _ _ _ _ _ _ N

Draw an AC Sine Wave and label the voltages and basic parts.

Unit 12 - Examination

Name: _____

1. When a wire cuts through a magnetic field, what determines the amount of voltage induced in the wire. (Circle as many as apply) (1) the rate of motion of the wire (2) the number of wires used (3) what direction the wire is being moved in (4) the strength of the magnetic field.

2. In transformers we have a _____ and _____ coil.

3. When hooking transformers in parallel, they must be _____ properly to avoid burn out.

4. Refer to Fig. #1 Page 5
   (1) Circle (+) or (-) on secondary of transformers
   (2) Give total voltage to load
   (3) Indicate current flow in all wires by arrows
   (4) Are these transformers in phase?

5. Draw a (1) Single pole, single throw relay
   (2) Single pole, double throw relay
   (3) Double pole, double throw relay

   Show the electromagnet, the return spring, and the contacts.

6. When choosing a relay, what three things should you keep in mind? (Choose 3)

   (1) Type of switching action (2) Current rating of contacts (3) Voltage and frequency of coil. (4) Type of equipment it is off of.

7. In AC current we have resistance and something extra affecting current flow, it is called (a) heat (b) impedence (c) frequency (d) inductance (e) reactance

8. The combined effect of both factors mentioned above is called (a) impedence (b) inductance (c) resistance (d) Henry

9. In a circle graph of one cycle of electricity, what is the electron doing at a phase angle of 180°? (a) moving fast to the right (b) moving slow to the left (c) stopped (d) moving fast to the left

10. Identify the following motors by these letters; (1) CS _____
    (2) CSR _____
    (3) PSC _____

11. Which motor has both the most thrust and good running efficiency?
    (a) CS (b) CSR (c) PSC (d) Shaded pole

12. What is the safest and most accurate way to check a fuse to see if it is bad or good?

_____

13. When sizing a relays contacts, what two AC ratings will have to be known?

_____

_____

14. When sizing fuses for a condensing unit, why is it important to pick a fuse with a time delay built into it? _____

_____

_____

15. When checking controls wired in series to find which control is bad, how should you connect your meter and what procedure should be followed?

_____

_____

16. If there is another circuit paralleling the circuit in question #15., how should you vary your procedure for checking the circuit in #15.

_____

_____

17. In CSR system, the Run and Start capacitors are in series with the start winding until the pickup voltage is reached. (True or False)

18. When checking a capacitors MFD with a Simpson meter and amprobe-draw a schematic of how you would connect meters and power cord, to get your readings. Use back of test paper.

19. Explain how to check a compressor for open or shorted windings.

20. Explain how to check a compressor for grounded windings.

21. The rule for voltage ratings on all capacitors is they must be _____ _____the capacitor being replaced.

22. On start capacitor, the MFD rating of a replacement must be _____ but not greater than _____of the capacitor being replaced.

23. When replacing a Run capacitor the MFD may vary no more than _____.

24. When connecting capacitors in parallel the voltage rating must be _____ the original capacitor and to find the total MFD you would _____.

25. When connecting capacitors in series, the voltages are _____ and must at least _____the voltage of the capacitor being replaced. The MFD rating would be formed by using the formula c._____.

26. Is a step down or step up transformer used on the electrical pole outside the house to get the proper voltage into the house. _____

27. When putting a SPST switch into a 110V circuit, which leg of the circuit do you break? _____.

28. When shutting off a 220V circuit, is it advisable to use a SPDT switch? _____.

29. Name the type of single phase motor is shown in figure II, page 5 _____ Lable the three legs.

30. What two methods can be used to remove the starting capacitor from the starting winding circuit in a single phase motor? _____ _____

31. Assuming the ratings were the same, could you substitute a running capacitor in place of a starting capacitor? _____ _____

32. Which capacitor, starting or running, would normally be a <u>wet</u> capacitor? _____

33. In #32, what does the term "wet" mean to you? _____ _____

34. Explain how a split phase motor operates. _____ _____

35. Draw a schematic of the following type of motors. (Use back of test paper)
(a) Permanent Split Capacitor (b) Capacitor Start Capacitor Run with a potential relay or a Back EMF Relay. Number terminals on the relay. _____

36. Explain how a Shaded Pole motor works. _____
_____.
(Use back if needed.)

37. Which motor is most commonly used for hermetic compressors? _____
_____.

38. When adding a start kit to a condensing unit, what does the kit consist of?
_____.

39. Explain what function a potential relay does and how it operates? _____
_____
_____.

40. In CSR system, the start capacitor is connected to Terminal 2 of the Potential Relay and the start winding. (True or False)

41. In CSR system, the start capacitor is connected to Terminal 1 of the Potential Relay and the run winding. (True or False)

42. In CSR system, the Run and Start capacitors are in parallel up until pickup voltage is reached. (True or False)

Fig # 1

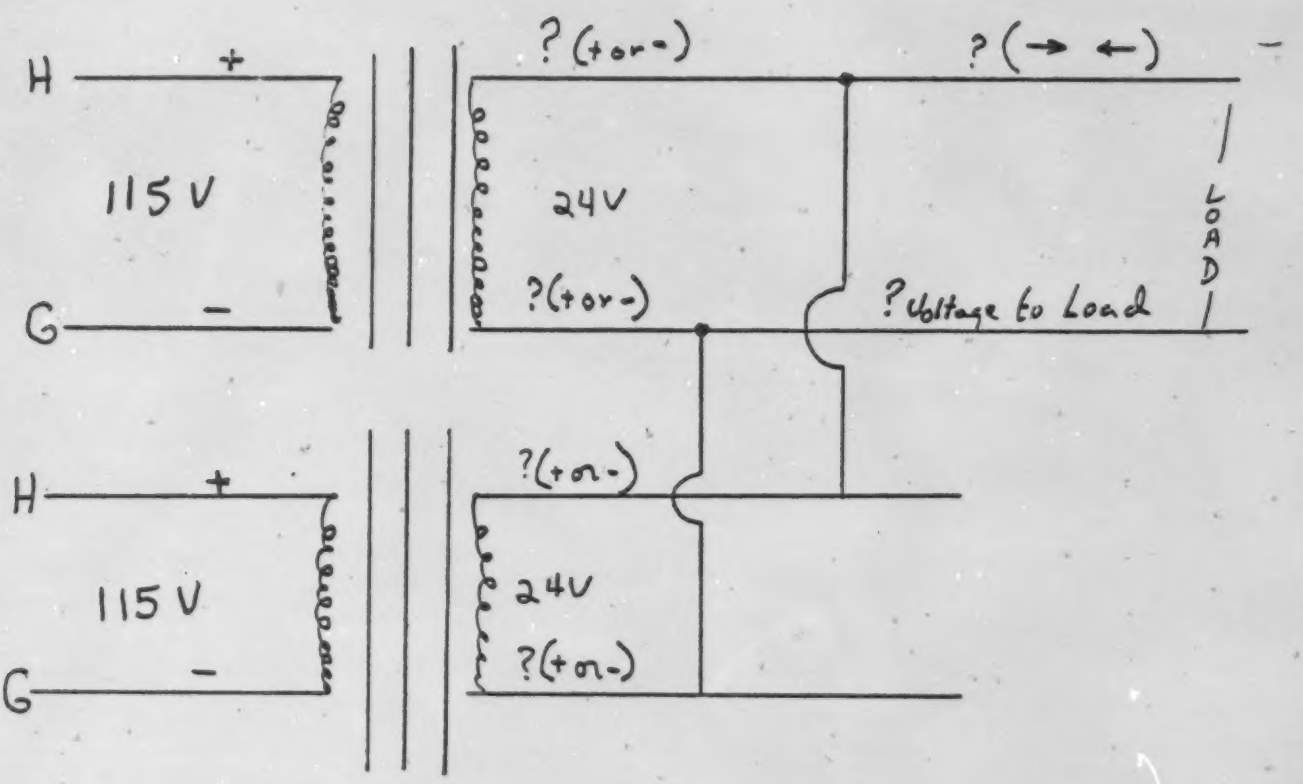
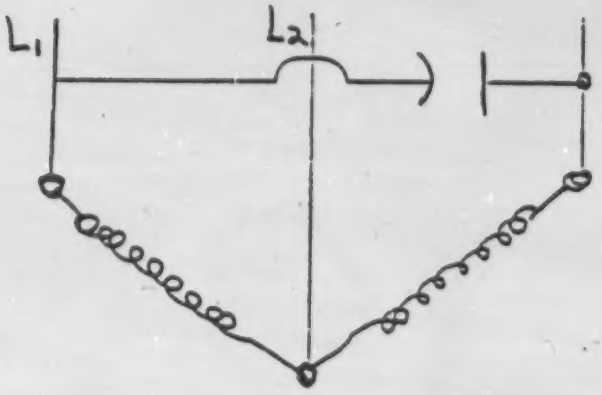


Fig # 2



AREA - HVACS ELECTRICAL

Unit 13 - Basic Control Systems Line Voltage

I. Instructional Objectives
To train students in the theory of operation, installation and servicing of domestic refrigerator controls, domestic freezer controls, commercial refrigeration controls, combinations and variations of above system. Student will learn principles of electrical controls used in air conditioning, refrigeration and solar. Main emphasis is placed on motor starting and safety controls. Student will learn both installation and service information.

II. Reference Materials:
Electricity for Refrigeration, Heating and Air Conditioning, 3, 7, 8
Carrier GTE Series, 3, 7, 8, 9, 10
Lennox Phase II(S) Electric
Workbench Guide to Electronic Troubleshooting-12.

III. Visual Aids
Carrier GTE Series Slide program (3,7,8,9,10)
Honeywell Motor Overheads

IV. Method Performance Conditions
Given domestic refrigerator, window air conditioner, central air conditioner, commercial refrigeration, solar electrical panels, in the lab.

V. Outline

1. Electrical safety
2. Review of Electric Motor Principles
3. Electric Motor Repair and Trouble Shooting
4. Controls
   A. Sensing elements
   B. Circuit electricity
5. Control Functions
   A. Temperature
   B. Limit and safety controls
   C. Fan controls
   D. Humidity controls
   E. Ignition controls
6. Refrigeration control systems

7. Summer Air Conditioning Systems

8. Winter Air Conditioning Systems

9. Fundamentals of Servicing

   A. Complaint diagnosis
   B. Record Significant Conditions
   C. Areas of Complaints
   D. Possible Causes
   E. Recommended Actions

VI. Student Evaluation Parameters

Student will be able to wire and troubleshoot the following equipment. Total understanding of all components will be documented through pictorial-schematic and actual wiring of units. Domestic refrigerator, window air conditioners, solar pumps and fans, central air conditioners, commercial refrigeration.

VII. Sequence of Instruction

1. Read all reference materials.

2. View all visual aids.

3. Perform all lab tasks.

4. Take unit tests.

Unit 13 - Lab Workbook

First Lab Assignment

1. The first week is taken up by familiarizing oneself with the students' level of electrical understanding. Try to bring all students to an equal level to start the course out from.
2. Get the students familiar with the equipment in general. Brief explanation of lab equipment. Review of use of testing meters.
3. Assignments to be turned in the following week.

   (Bard 2 ton condensing unit)

   A. Component checks with testing meters
      1. check main power coming in
         a. single phase
         b. three phase
      2. check fuses
         a. in circuit
         b. taken out of circuit
      3. check contactor
         a. contacts
         b. coil

4. check compressor motor
    a. open windings
    b. shorted windings
    c. grounded windings
5. check fan motor-condensing unit
    a. open
    b. shorted
    c. grounded
    d. run, start, common
6. check capacitor
    a. use capacitor testors (two types)
    b. use amprobe and Simpson 260 meters
        1. two run capacitors
        2. start capacitor
            (a) check for open
            (b) check for short
            (c) check for Microfarad Rating - compare to label rating
            (d) use mathematics formula
7. check all wires
    a. resistance checks
    b. end connectors

Second Lab Assignment

1. Lab assignments turned in the following week.
    A. Give a detailed explanation of the purpose and operation of a potential relay.
    B. Check the potential relay on the Bard Unit.

1. check contacts
2. check coil
3. check drop out voltage
4. check pull in voltage

C. Memorize three important terminals

1. Terminal #1 - what is it connected to?
2. Terminal #2 - What is it connected to?
3. Terminal #3 - What is it connected to?

D. Give an explanation of compressors heater circuit. (Bard)

E. Explain three terminal run capacitor.

D. How does it work?

Third Lab Assignment

Lab assignments to be turned in at end of period.

1. Draw a block diagram of a Bard Condensing Unit.
   A. Show all components.
      a. use straight lines to indicate wires.
      b. when one wire crosses another, loop the line
      c. use no color coded wiring, assume all wires are the same color
2. Object is to find where wires come from and carry current to.
3. Explain why they go where they do and what they do when they get there.
   A. motor operation
   B. Capacitor
   C. Contactor, etc.

Fourth Lab Assignment

1. Draw a ladder type schematic of the Bard Condensing Unit.
2. Explain in a step-by-step procedure how power is brought to each component.
3. Do this with the thought of learning to read schematic in mind.
4. Pull all wires off of Bard Unit and learn to rewire without the use of schematic. Use reasoning from ladder schematic step-by-step.

Fifth Lab Assignment

Assignment to be turned in at end of class period.

1. Draw a ladder type schematic of the Amana Condensing Unit.
   A. How does this unit differ from the Bard Unit?
   B. Take all wires off of Bard Unit.

      Step-by-step think through the rewiring of the unit.
   C. Review all wiring and controls gone over thus far in the course.

      Be prepared for questions on all wiring.

Sixth Lab Assignment

1. Make two ladder schematics of two window units of your choice.
2. Wire both units. All wires will be removed before you start your examination of this unit.
3. Write a step-by-step explanation of why you are wiring each component in this manner.
4. How does a window unit differ from central air conditioning unit wiring?

Seventh Lab Assignment

Hand assignment in before classroom lecture.

1. Give a detailed account of anything you found to be still unclear after taking the mid-term exam. (You should have knowl all questions on exam).
2. All questions presented will be gone over in classroom to insure students capability to handle these items at any future contact.

Eighth Lab Assignment

Assignment to be turned in next week.

1. Check wiring on walk-in freezer. Go over all wiring including timer mechanism and evaporator section.

2. Write up a schematic drawing of the freezer.

   A. Show the following in ladder schematic form.

      a. condensing unit
      b. timer circuitry
      c. evaporator fan
      d. all klivon or thermal switching controls
      e. defrost heaters, etc.

3. Write up a step-by-step defrost cycle process. Start system with iced coil and bring completely through defrost back to normal operation.

Ninth Lab Assignment

Assignment to be turned in at end of class.

1. Draw a ladder schematic of a walk-in refrigeration unit.

2. Draw a ladder schematic of any typical condensing unit used on commercial refrigeration equipment. Use any one of the condensing units available in our lab.

3. Explain operation of a current relay.

   A. Check contacts

   B. Check coil

4. Show how to connect a start and run capacitor to a system with a current relay. Draw a schematic form.

Tenth Lab Assignment

Assignment to be turned in next week.

1. Pick any domestic refrigerator freezer combination unit.

   A. Go over all wiring and check routing of wiring through unit.

   B. Check all components.

      a. explain how you check with each meter used.
      b. if components are bad, make a list and we will replace them.

2. Draw a schematic of two different domestic refrigerators.
3. Explain operation of a hot wire relay.
   A. Show how to wire in a hot wire relay.
   B. How would capacitors be added to this type system?
4. Do you prefer working on these domestic units or commercial units?

Eleventh Lab Assignment

Assignment to be turned in before class ends.

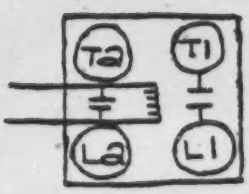
1. Check over ice cubers.
   A. Check through wiring and draw a schematic of one of our units.
2. Review any equipment you do not feel you have covered closely enough.
3. Are there any areas you feel should have been covered that weren't?

240V 1-Ph 60cy

24V

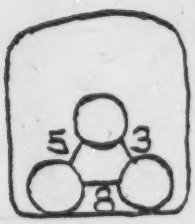
Blower Motor

Blower Motor Capacitor



Contactor

Compressor Capacitor



Compressor

Overload

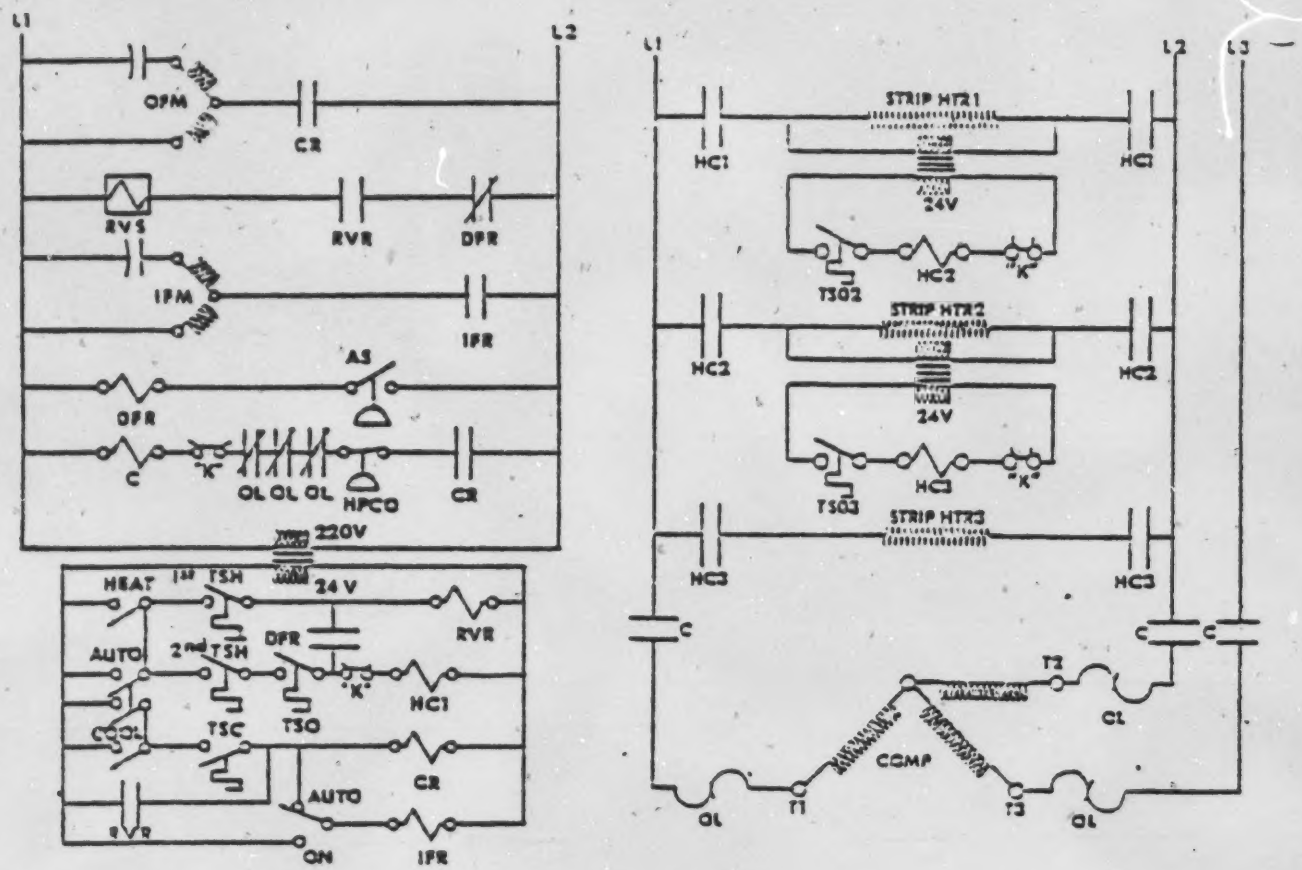
A) Wire the above unit.
Draw nice straigh lines indicating wires.
Connect all components properly to make unit run.
Connect 230V and 24V lines.
Lable all motor terminals (Run, Start, or Common).

B) Draw in hard start components.
Wire it properly to existing condensing unit.
Label all terminals (there should be at least three numbers)

C) Draw a Schematic of the wiring diagram that you have just completed..
Use the two line method as shown in class.
Draw it on the back of this paper.
Include the hard start kit.

Schematic

Questions 1 thru 26 should be answered from looking at this schematic.



Ledger

Scan Tron Letters	
A	OFM -outdoor fan motor
B	CR -compressor relay
C	RVS -reversing vale solenoid
D	RVR -reversing valve relay
E	DFR -defrost relay
AB	IFM -indoor fan motor
AC	IFR -indoor fan relay
AD	AS -air pressure switch
AE	C -contactor
BC	"K" -Klixon
BD	OL -overload
BE	HPCO-high pressure cutout
CD	TDR -time delay relay
CE	TSH -heating thermostat
DE	TSO -outdoor thermostat
E	HC -heater contactor
ABC	TSC -cooling thermostat
ABD	COMP-compressor

1. How many line voltage "load" circuits are shown in the diagram?

   A. 1
   B. 5
   C. 6
   D. 11
   E. 12

2. How many low voltage "load" circuits are shown in the diagram?

   A. 1
   B. 2
   C. 4
   D. 5
   E. 6

3. What relay controls the outdoor fan motor? Choose answers from ledger.

4. With the heat switch close and the first TSH calling for heat the CR coil will be energized.

   True or False

5. When the "C" contactor coil is energized, how many switches change position?

   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

6. With the "Auto-On" switch in the "On" position, what effect will the closing of the thermostat have on the indoor fan relay?

   A. Cause relay to close
   B. Make fan run
   C. No effect
   D. Burn it up
   E. Overload it

7. What is the normal position of the contacts controlled by coil "C"?

   A. Midposition
   B. Normally closed
   C. Normally open
   D. Abnormal
   E. Burned out

8. With the "Auto-On" switch in the "auto position, the indoor fan will start before the outdoor fan.

   True or False

9. What operates the switch labeled "Cool"?

   A. Electro magnetic force
   B. Coil
   C. "AS"
   D. Your hand
   E. Room temperature

10. Not counting the fused disconnect switch, how many switches are in each line to the compressor?

   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

11. How many sets of contacts are on the reversing valve relay?

   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

12. What switches must be closed to energize the first resistance heater contactor coil? (Choose any that apply.)

   A. Heat, 1st TSH, DFR, K
   B. Head, 2nd TSH, TSO, K
   C. Cool, 2nd TSH, TSO, K
   D. Auto, 1st TSH, DFR

13. How many switches would have to be checked if the"C"coil did not energize on a call for heat? (Line and low voltage)

   A. 2
   B. 4
   C. 6
   D. 8
   E. 10

14. What determines the number of resistance heaters that are turned on when the second step of the heating thermostat closes? (Choose answers from ledger)

15. Assuming all switches set properly and all load devices functioning satisfactorily, is it possible to turn on the number three (3) strip heater without turning on number one (1)?

   A. Yes
   B. No

16. Assuming all switches correctly set and all load devices functioning properly, in the diagram shown, is it possible to operate the number one strip heater without compressor operation?

   A. Yes
   B. No

17. With the manual fan switch in the position shown, the unit heat switch closed, what effect will the closing of the first step of the heating thermostat have on the indoor fan motor?

    A. No effect
    B. Start it running
    C. Short it out
    D. Can not happen
    E. None of the above

18. With the manual fan switch in the "On" position, what effect will the closing of the first step of the heating thermostat have on the indoor fan motor?

    A. Make it run
    B. Turn it off
    C. No effect
    D. Should not be done
    E. None of these

19. Assume the unit switch setting satisfactory and all loads functioning properly with the manual switch in the "Heat" position, the first step of the thermostat closes. How many coils will be energized before heat is properly functioning?

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

20. The RVR and DFR switch(s) are in the reversing valve solenoid circuit and their normal positions respectively are normally open, and normally closed.

    True or False

21. If the contactor coil does not energize when the compressor relay coil is energized, how many switches should be checked.

    A. 2
    B. 4
    C. 6
    D. 8
    E. None of these

22. The first step heating thermostat is closed, the second step is not. The unit goes on the defrost cycle and the first strip heater unit comes on. Can this be correct?

    A. Yes
    B. No

23. With the compressor and all three strip heaters in operation, the "Klixon" for the first strip heater contactor opens due to overheating. What happens to the remaining two strip heaters?

    A. Burn up
    B. Go off
    C. Stay on
    D. Can not happen
    E. None of these

24. From an examination of the diagram, what would the air pressure have to do to close the air pressure switch (AS)?

A. Increase
B. Decrease

25. The overload in the L_2 circuit to the compressor opens during operation. If all strip heater are "on" at the time, will they be turned "off"?

A. Yes
B. No

26. When you arrive on the job, the compressor and #1 & #3 strip heaters are operating. The unit is wired correctly. Where is your problem?

END

A. HC2 contacts
B. TSO2 contacts
C. HC2 coil
D. "K"
E. Strip HTR2

27. On our Electrical Distribution systems throughout the country transmission voltages are increased in order to _____ Choose any that apply

A. Make crackal noise on hot days
B. Heat the conductor wire
C. Cause a greater resistance to the insulator
D. Reduce the necessary current flow

28. With a reduction in current flow at high voltage the size of conductor wires can be reduced. T or F

29. Utility franchises generally permit variations of 10%. T or F

30. Electrical power is a fraction of Volts times Ohms. T or F

31. A typical Domestic Electrical Service would be:
Choose any that apply.

A. 1 phase - 110/280V - 300 AMP
B. 1 phase - 120/240V - 100 AMP
C. 3 phase - 240/110V - 200 AMP
D. 2 phase - 110/220V- 60 AMP

32. Commercial, Industrial, Plants use 3 phase power. T or F.

33. If voltage levels are dropped below normal what effect does it have on a motor. Choose any that apply

A. Start and pulling torque. Decreased.
B. Starting current increased.
C. Efficiency decreased.
D. Full load current increased.
E. Life expectancy of motor increased.

34. Where motor of 3Hp and larger are involved, there is a preferance for three-phase power. T or F

35. With a 3 phase Delta Transformer Connection we can obtain the following single-phase voltages. (Choose any that apply)

A. 110/220
B. 120/240
C. 208/120
D. 115/230
E. 220/240

36. With a 3 phase "Y" connection we can obtain the following single-phase voltage (Choose any that apply)
A. 208/120
B. 277/160
C. 220/127
D. 240/480
E. 110/220

37. A potential relay is used to remove a run capacitor from an electrical circuit. T or F

38. A potential relay uses back electromotive force to de-energize its coil. T or F

39. The contacts on a potential relay are normally closed

True or False

40. The coil in a potential relay is between terminals. (Choose one)

A. 6 and 4
B. 4 and 3
C. 2 and 5
D. 1 and 2

41. A start capacitor is placed into a motor circuit to give the motor more starting revolutions per minute.

True or False

42. A start capacitor is wired to the start leg of a motor and the run capacitor is wired to the run leg.

True or False

43. A potential relay relies on gravity to close its contacts.

True or False

44. Pressure safety controls are wired into the electrical circuit to shut the unit off on a high or low pressure situation.

True or False

45. A 3 pole, 40 AMP, 24 volt coil contractor indicates a unit that is made up of. (Choose one)

A. 3 separate sets of contact, that will handle 40 AMPS each, and an operating coil activated by 24 volts
B. One set of contact with 3 places to tie on, that takes 40 Amps to operate and can handle 24 volts through the contacts
C. Three seperate contacts which when close by a 24 Volt power source all come together and produce 40 amps.

46. The Bard condensing units use a run capacitor in series with the run winding to keep the compressor warm in off cycle.

True or False

47. The Amana unit differs from the Bard in that it has no heater.

True of False

48. A run capacitor can be used in place of a start but a start capacitor can not be used in place of a run.

True or False

49. A PSC motor has a start capacitor.

True or False

50. A shaded pole motor has more running torch than a PSC.

True or False

1. How many line voltage "load" circuits are shown in the diagram? Name them.

_____

2. How many low voltage "load" circuits are shown in the diagram? Name them.

_____

3. What relay controls the outdoor fan motor? _____

4. What two switches must be closed to energize the compressor relay coil?

_____

5. When the compressor relay coil is energized, how many switches will change position? _____ What position will they change to, open or closed? _____ Will they complete the circuits to any loads? _____ If so, name them _____

_____

6. With the "Auto-On" switch in the "On" position, what effect will the closing of the thermostat have on the indoor fan relay? _____

_____

7. How many sets of contacts in the switch controlled by the coil "C"? What is their normal position? _____

8. With the "Auto-On" switch in the "Auto" position, the indoor fan will start before the outdoor fan. TRUE or FALSE (circle answer)

9. What operates the switch labeled "Cool"? _____

10. Not counting the fused discounnect switch, how many switches are in each line to the compressor? _____

11. How many sets of contacts are on the reversing valve relay? _____

_____

12. What switches must be closed toenergize the first resistance heater contactor coil? _____

_____

13. What forces close the switch(s) in #12 above? _____

_____

14. What determines the number of resistance heaters that are turned on when the second step of the heating thermostat closes? _____

_____

15. Assuming all switches set properly and all load devices functioning satisfactorily, is it possible to turn on the number three(3) strip heater without turning on number one (1)? _____

16. Assuming all switches correctly set and all load devices functioning properly, in the diagram shown, is it possible to operate the number one strip heater without compressor operation? _____

17. With the manual fan switch in the position shown, the unit heat switch closed, what effect will the closing of the first step of the heating thermostat have on the indoor fan motor? _____

18. With the manual fan switch in the "On" position, what effect will the closing of the first step of the heating thermostat have on the indoor fan motor? _____

19. Assume the unit switch setting satisfactory and all loads functioning properly, with the manual switch in the "Heat" position, the first step of the thermostst closes. Describe the step by step elecrical action until all four (4) required loads to heat are properly functioning.

20. What switch(s) are in the reversing valve solenoid circuit and what are (is) their normal position? _____

21. If the contactor coil does not energize when the compressor relay coil is energized, how many switches could be checked? Name them. _____

_____

22. The first step heating thermostat is closed, the second step is not. The unit goes on the defrost cycle and the first strip heater unit comes on. Can this be correct? If so, how does the heater become energized with the 2nd step of the heating thermostat open? _____

_____

23. With the compressor and all three strip heaters in operation, the "Klixon" for the first strip heater contactor opens due to overheating. What happens to the remaining two strip heaters? _____

_____

24. From an examination of the diagram, what would the air pressure have to do to close the air pressure switch (AS), increase or decrease._____

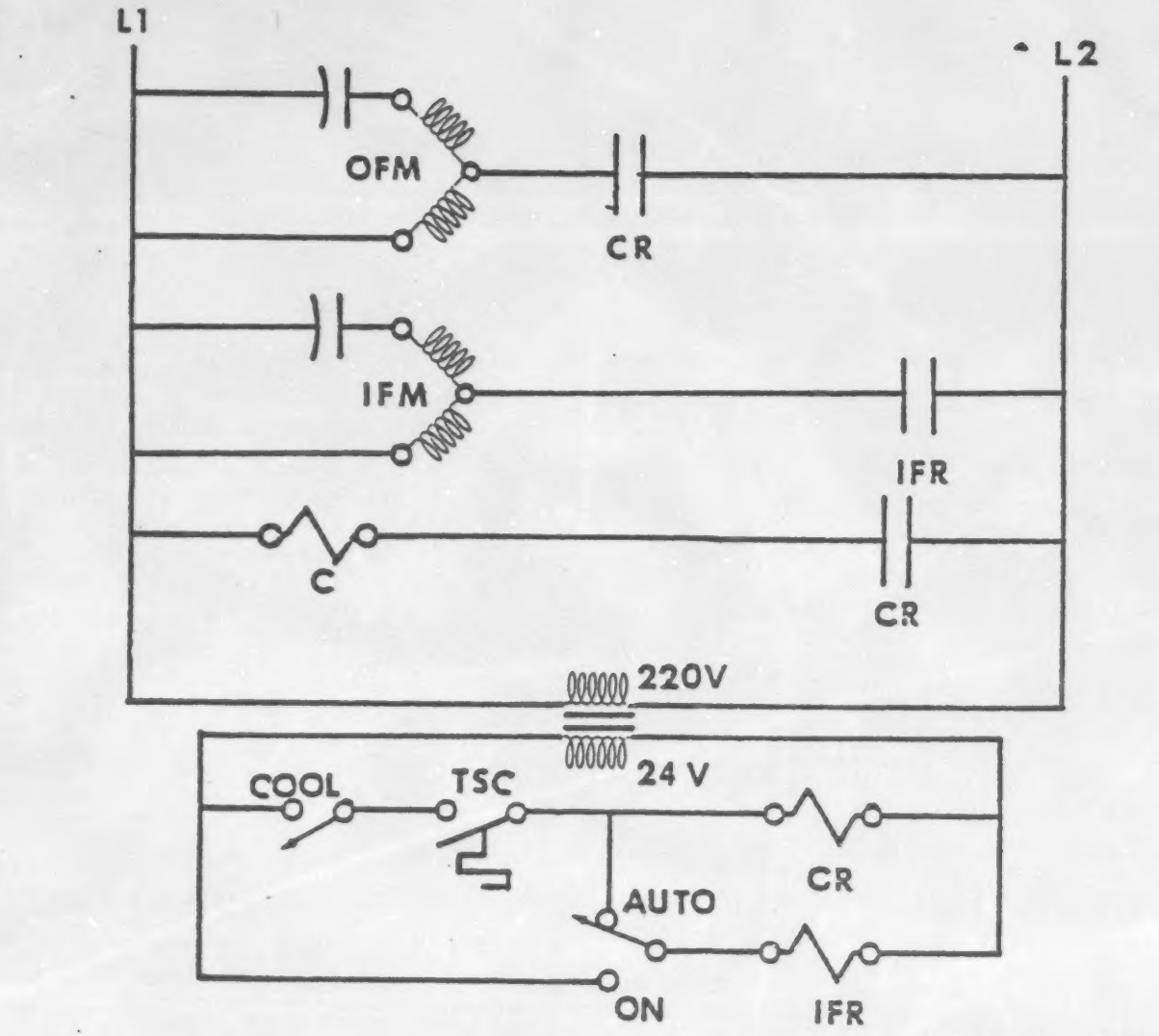
25. The overload in the L_2 circuit to the compressor opens during operation. How does this stop the compressor? If all strip heater are "on" at the time, will they be turned "off"? _____

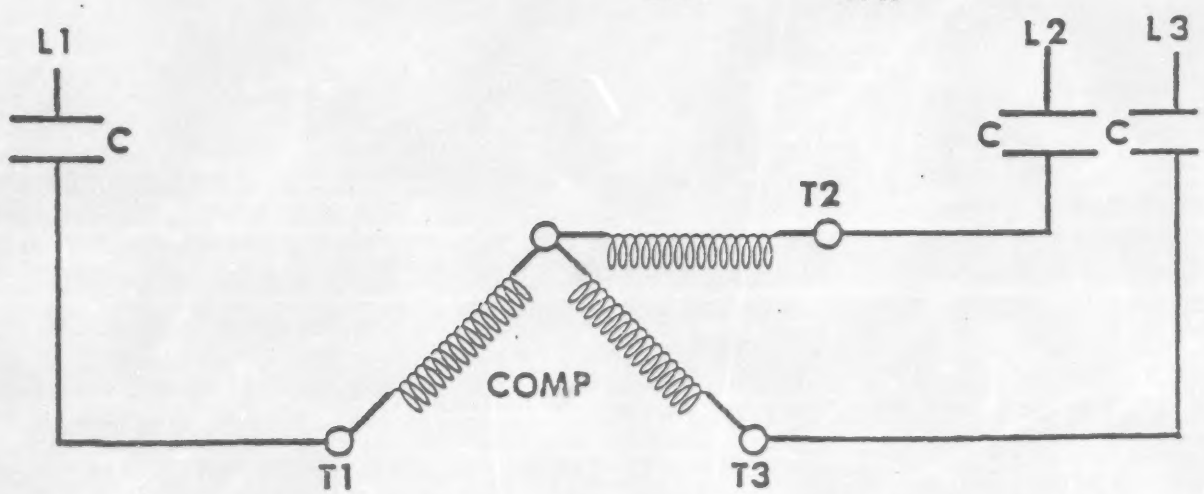
_____

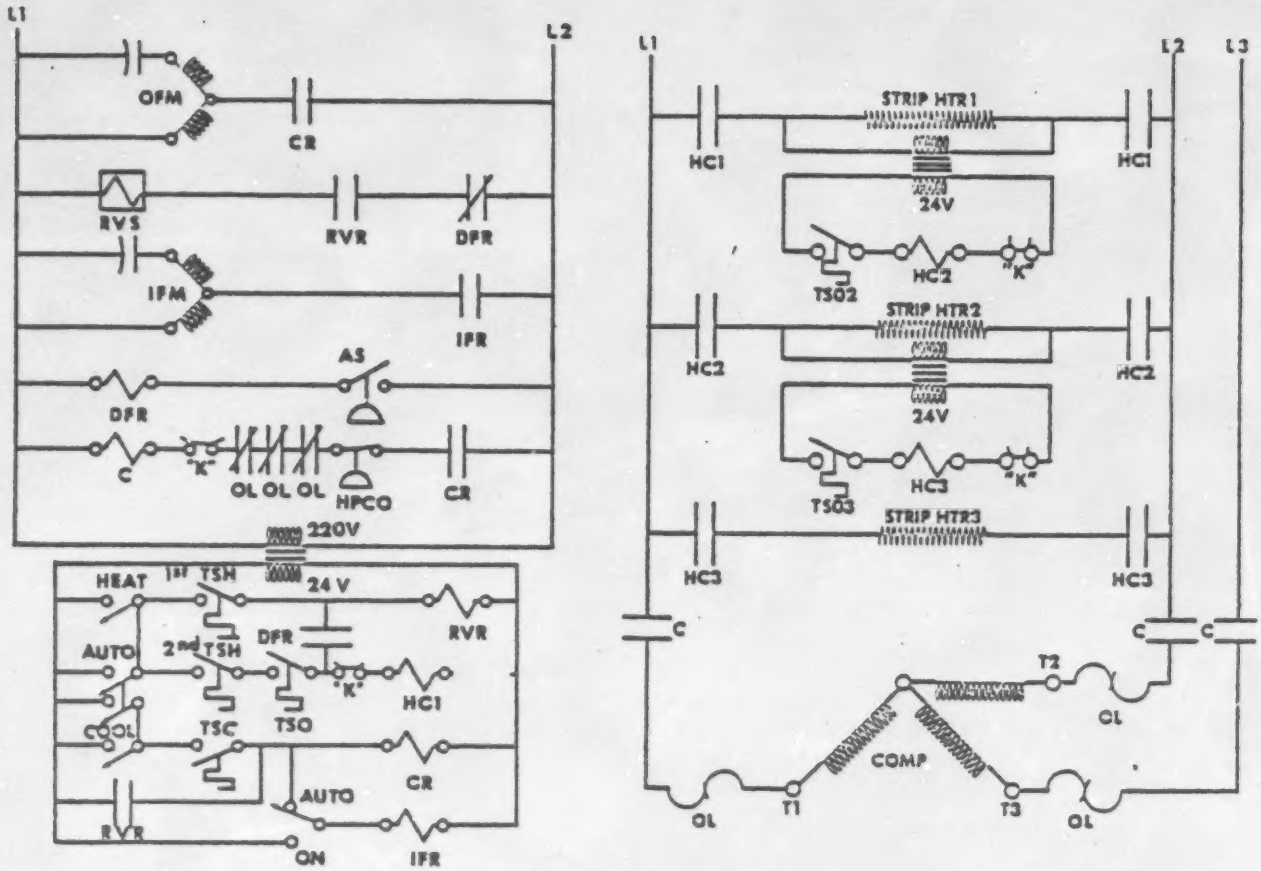
26. When you arrive on the job, the compressor and #1 & #3 strip heaters are operating. The unit is wired correctly. Where is your problem? _____

_____

1


L1
L2
OFM
CR
IFM
IFR
C
CR
220V
24 V
COOL
TSC
CR
AUTO
ON
IFR


L1
C
L2
L3
C
C
T2
COMP
T1
T3



OFM - outdoor fan motor
CR - compressor relay
RVS - reversing valve solenoid
RVR - reversing valve relay
DFR - defrost relay
IFM - indoor fan motor
IFR - indoor fan relay
AS - air pressure switch
C - contactor
"K" - Klixon
OL - overload
HPCO - high pressure cutout
TDR - time delay relay
TSH - heating thermostat
TSO - outdoor thermostat
HC - heater contactor
TSC - cooling thermostat
COMP - compressor

27. On our Electrical Distribution systems throughout the country transmission voltages are increased in order to _____ Circle one
    a) Make crackel noise on hot days
    b) Heat the conductor wire
    c) Cause a greater resistance to the insulator
    d) Reduce the necessary current flow

28. With a reduction in current flow at high voltage the size of conductor wires can be reduced. T or F

29. Utility franchises generally permit variations of 10%. T or F

30. Electrical power is a fraction of Volts times Ohms. T or F

31. A typical Domestic Electrical Service would be:
    Circle one
    a) 1 phase - 110/280V - 300 AMP
    b) 1 phase - 120/240V - 100 AMP
    c) 3 phase - 240/110V - 200 AMP
    d) 2 phase - 110/220V- 60 AMP

32. Commercial, Industrial, Plants use 3 phase power. T or F.

33. If voltage levels are dropped below normal what effect does it have on a motor.
    Circle all that apply.
    a) Start and pulling torque. Decreased.
    b) Starting current increased.
    c) Efficiency decreased.
    d) Full load current increased.
    e) Life expectancy of motor increased.

34. Where motor of 3Hp and larger are involved, there is a preference for three-phase power. T or F

35. With a 3 phase Delta Transformer Connection we can obtain the following single-phase voltages.
    Circle any that apply.
    a) 110/220
    b) 120/240
    c) 208/120
    d) 115/230
    e) 220/240

36. With a 3 phase "Y" connection we can obtain the following single-phase voltage
    a) 208/120
    b) 277/160
    c) 220/127
    d) 240/480
    e) 110/220

37. A potential relay is used to remove a run capacitor from an electrical circuit. T or F

38. A potential relay uses back electromotive force to de-energize its coil. T or F

39. The contacts on a potential relay are normally closed. T or F

40. The coil in a potential relay is between terminals. Circle one.
    a) 6 and 4
    b) 4 and 3
    c) 2 and 5
    d) 1 and 2

41. A start capacitor is placed into a motor circuit to give the motor more starting revolutions per minute. T or F

42. A start capacitor is wired to the start leg of a motor and the run capacitor is wired to the run leg. T or F.

43. Explain how our Bard Condensing Units are wired to keep the compressor oil hot. How does this differ from the Amana Units?
    a)

    b)

44. A potential relay relies on gravity to close its contacts. T or F

45. Pressure safety controls are wired into the electrical circuit to shut the unit off on a high or low pressure situation. T or F

46. A 3 pole, 40 AMP, 240 volt coil contractor indicates a unit that is made up of: Circle one
    a) 3 seperate sets of contact, that will handle 40 AMPS each, and an operating coil activated by 24 volts
    b) One set of contact with 3 places to tie on, that takes 40 Amps to operate and can handle 24 volts through the contacts
    c) Three seperate contacts which when close by a 24 Volt power source all come together and produce 40 amps.

AREA - HVACS ELECTRICAL

Unit 14 - Control Systems Low Voltage and Line

I. Instructional Objectives
The student will learn the necessary physical skills to install and troubleshoot low voltage and line voltage control systems. Student will learn how to properly select new and replacement control components.

II. Reference Materials
Electric Controls for Refrigeration and Air Conditioning, Langley (all of book).
Honeywell Cooling Controls
Lennox Phase III(S) Electrical Considerations
Lennox Phase III(S) Controls
RETA Control Theory and Fundamentals Part I
Carrier GTE, Series 9

III. Visual Aids
Overheads of Drawings in Text 1
Overheads of Honeywell Controls
Carrier Slides GTE 9

IV. Method Performance Conditions
Student will be provided with actual furnaces, solar control boards, air conditioners, etc. to perform on.

V. Outline
1. Transformers and Thermostats
   A. Why we use low voltage
   B. Transformers - sizing, wiring and trouble shooting
   C. Thermostats - theory, types circuitry, installation, calibration and troubleshooting
   D. Lab: transformers
2. Advanced thermostats
   A. Thermostats continued, night set back, microprocessors
   B. Lab: Thermostats
3. Contractors, motor starters, and relays
   A. Applications
   B. Types

C. Troubleshooting

D. Lab: relays, starters and contactors

4. Pressure switches, defrost solonoids, timers and low ambient controls.

A. Settings

B. Applications

C. Lab: set pressure switches and defrost controls

5. Evaporator blower controls

A. Single and multiple speeds

B. Problems

C. Humidifier and EAC wiring

D. Sail switches

6. Test

7. Combine controls into a system

A. Applications

B. Lab: wire furnaces and A/C

8. Lab: Wire and draw furnaces and A/C

9. Special Control Systems

Lab: wire simulated panels and furnaces and boilers

10. Heat pump control systems

Lab: Wire rooftop systems and heat pumps

11. Test

Outline

A. Thermostats

1. theory of operation
2. circuitry
3. installation
4. calibration
5. troubleshooting

B. Transformers

1. sizing
2. wiring
3. troubleshooting

C. Contactors

D. Motor starters

1. overload protection
2. theory of operation, application
3. troubleshooting

E. Evaporator blower controls

1. single and multiple speed
2. problems encountered
3. relation to accessories

F. Heat pump reversing valves and liquid solenoid valves

1. theory of operation
2. troubleshooting

G. Pressure switches

H. Defrost solenoids

I. Timers

J. Methods of low ambient control

K. Combine above controls into systems

L. Solar Components

1. central control panel
2. zone control
   a. water
   b. air
3. temperature sensing and activating components

VI. Student Evaluation Parameters

Student will demonstrate ability to wire all low voltage controls and most line controls and most line voltage components, including troubleshooting, bad components, crossreferencing new parts and installing.

VII. Sequence of Instruction

1. Read all reference materials.
2. View all visual aids
3. Work lab projects
4. Take Unit 14 tests
5. Discuss new low voltage solid state units being presented in today's market.

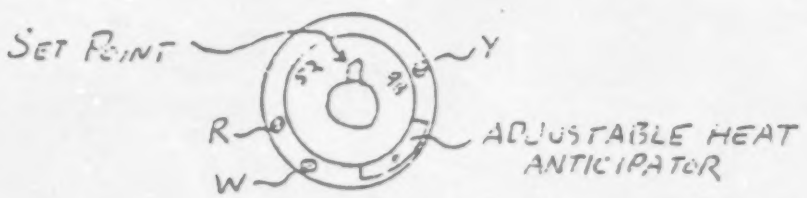
NAME_____

Unit 14 - Sample Lab Assignments

OBJECTIVE: To learn the internal circuitry of the Honeywell T87F - Q539 Thermostat subbase combination.

TOOLS AND MATERIALS REQUIRED: One Simpson 260 VOM, one small screw driver, one T87F thermostat, and one Q539 subbase.

1. Facing the dial of a T87F thermostat you will observe three screws around the perimeter and the adjustable heat anticipator scale. The screws and anticipator are labeled -



NOTE: During the following procedures, hold the label "Honeywell" level.

A. Connect a Simpson 260 to terminals R & W on the back of the T87F (Rxl scale, zero the meter) adjust set point to 98°F set heat anticipator to .10 AMPS, what is the reading?_____

B. Change set point to 52°F. What is the reading?_____

C. Change set point to 98°F and heat anticipator setting to 1.2 AMPS. What is the reading?_____

D. Is the heat anticipator in series or parallel with the mercury switch?

E. Using the formula $I^2R = W$ and assuming a current flow of one ampere, how many watts are disapated in A._____ in C._____

F. Convert the answers to the previous question to BTU.

G. Move one lead of the Simpson 260 from terminal W to Y, adjust set point to 98°F. What is the reading?_____

H. Change set point to 52°F. What is the reading?_____

I. What is the switching action of the Mercury switch?
a. SPST b. SPDT c. DPDT d. DPST

2. Using a pencil transfer the letter, color-code terminal designations from the front to the back of a Q539 subbase. Attach the T87F to the Q539 using the three screws on the T87F. Using a Simpson 260 answer the following:

A. With the subbase switches and thermostat set point set as indicated below. Geive the resistance between the terminals listed.

a. Cool-Auto-98°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

b. Cool-Auto-52°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

c. Cool-on-98°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

d. Cool-on-52°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

e. Off-Auto-98°F
Off-Auto52°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

f. Off-on-98°F
Off-on-52°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

g. Heat-Auto-52°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

h. Heat-Auto-98°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

i. Heat-on-52°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

j. Heat-on-98°F

R to W _____
R to B _____
R to G _____
R to Y _____
R to O _____
G to Y _____

B. a. Using the formula $E/R = I$ and assuming a voltage or 24 volts, how much current flows through the cooling anticipator?

b. Using the formula $I^2R = W$ how many watts are disapated?

How many BTU?

3. Using the information gained in number 3 draw a schematic diagram of the T87F, Q539 combination.

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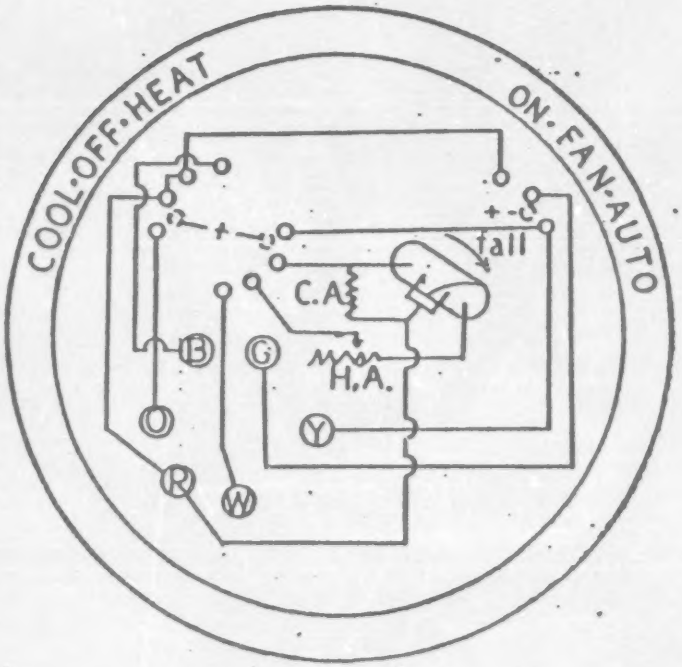
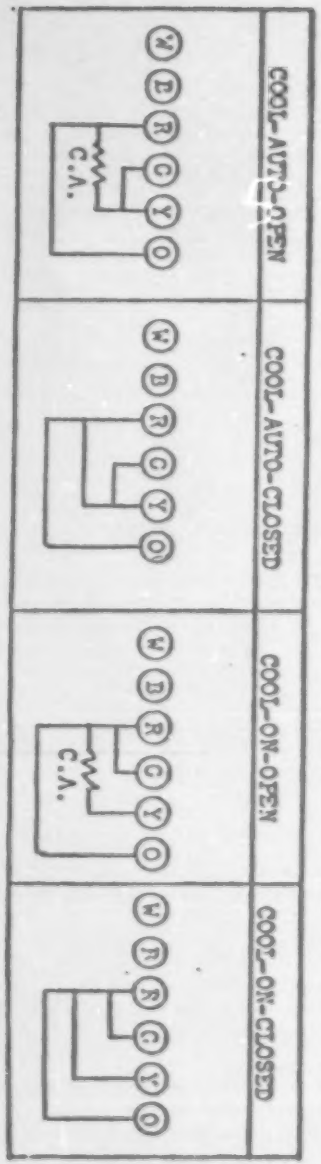
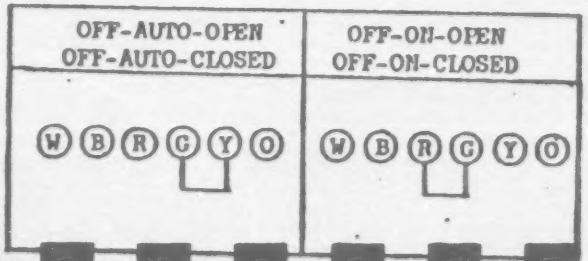


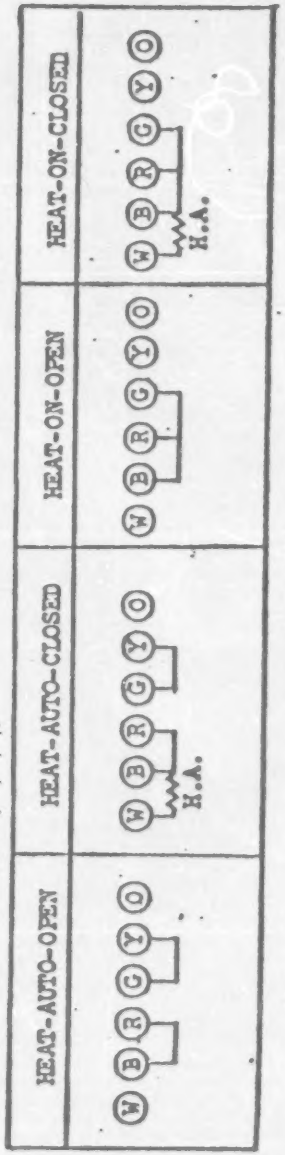
	BRYANT P/N	HONEYWELL P/N
THERMOSTAT SUB-BASE (EAC)	34427D17	T87F1388
SUB-BASE (GAC)	34427D28	Q539A1071
	34427D29	Q539A1089

LEGEND

SYSTEM SWITCH	FAN SWITCH	T'STAT BULB
COOL	ON	OPEN
OFF	AUTO	CLOSED
HEAT		







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THERMOSTAT

1. Identify model - characteristics.

2. Check resistance across terminals.
   Take readings in open position
   closed position.

3. Trace out on paper, wiring of subbase.

4. Note color scheme and markings on base.

5. Identify construction-bimettalic-mercury bulb.

6. Identify heat anticipator-variable or fixed type.

7. Recalibrate if necessary, using recalibration wrench.

8. Check thermostat operation
   Procedure: A. Turn down temp. setting to lowest point, switch in Heat position.
   B. Raise temp. setting until unit starts. Should be at room temp.
   C. Heating should stop when dial is turned down.

   Cooling: A. Lower setting until cooling starts.
   B. Raise setting above room temp-cooling should stop.

9. Check amperage draw setting-should be matched to setting of main gas operator valve or primary control or read on name plate.

   If not-check for amperage draw.
   A. Connect ammeter between terminals on subbase.
   B. Let system run for about a minute.
   C. Read ammeter.

TOOLS:
Thermostats, small screwdriver, paper, pencil, ohmmeter.

Transformers-Current Relay

1. Pick a transformer on any air conditioning unit.
2. Write down the electrical details (that is what the power is on Primary side, secondary side, number of leads on Primary side and secondary side, amps, etc.)
   Draw also what combination of wires you can use.
3. Using a volt meter check the voltage on secondary side.
4. Is this the rated amount?
5. Determine the voltage in primary side.
6. Describe how transformer functions.
7. How is the transformer rated.
8. Pick out a current relay - describe the relay how many terminals? Which ones are closed opened? Use an ohmeter to determine this.
9. Try to feed-out on what units they can be found.
10. Indicate on drawing the terminals that are normally closed or opened using the symbols for normally closed or opened.

Required materials: Tools-Transformer, current relays-ohmeter and ammeter.

LAB PROJECT

1. Pick a current relay and a potential relay from surplus parts room.
2. Draw each - indicating proper electrical symbols for normally open or closed switch.
3. State when a normally closed switch would open and normally open switch would close.
4. Find some other relays and using the proper electrical symbols, find which are open and closed. Draw each.
5. Draw a wiring diagram of a current relay and potential relay as they are found on some unit showing the related parts (like compressor, protector, start capacitor and run capacitor and their connections to potential or current relay.
6. If you can start a unit - use an ammeter to check amperage draw on any unit, also check voltage - is it normal as rated?

TOOLS: Ammeter, voltmeter, ohmmeter, current potential relays - paper, pencil and some floor units.

Unit 14 - Quiz 1

Directions: Muitiple Choice. PLEASE put correct answer for all problems on your Scan Tron Sheet. Also, please make sure your name is on the Scan Tron Sheet.

T or F 1. A permanent magnet must be recharged occasionally to keep the molecules properly arranged.

T or F 2. A magnetic field is used to convert electrical energy to mechanical energy in a generator.

3. Electrical current is:
   a. The movement of atoms within the material.
   b. The movement of the outer layer of electrons of the atoms of a conductor.
   c. The movement of all the electrons within an atom of a conductor.
   d. None of the above answers is correct.

4. When we apply an electrical force to a material and do not get a flow of "free" electrons, we:
   a. must increase the electrical force.
   b. call the material an insulator
   c. call the material a conductor
   d. None of the above answers is correct.

5. An Electromotive Force is:

___ a. a term developed by the automobile industry.

___ b. an alternating current developed by a battery.

___ c. the flow of current in one direction only.

___ d. None of the above answers is correct.

6. An alternating current generator requires an external power source to develop a strong magnetic field.

___ True ___ False

7. In a simple circuit of a 9 Volt battery and a 175 Ohm resistor we can find by Ohms Law that the current is:

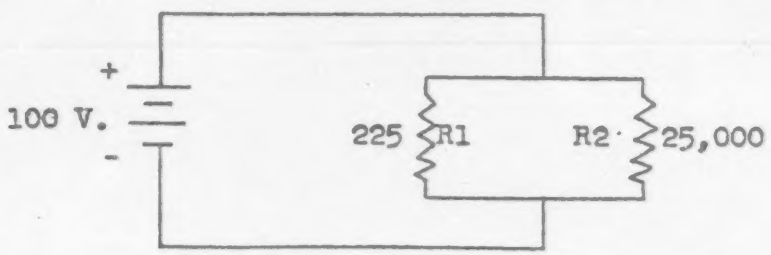
___ a. 6 amperes

___ b. .005 amperes

___ c. .514 amperes

___ d. .0514 amperes

8. In the following circuit the total resistance of the circuit is:



___ a. - 25,225 ohms

___ b. 222.9 ohms

___ c. 22.29 ohms

___ d. 225 ohms

9. The current flowing through the circuit in question No. 8 is:

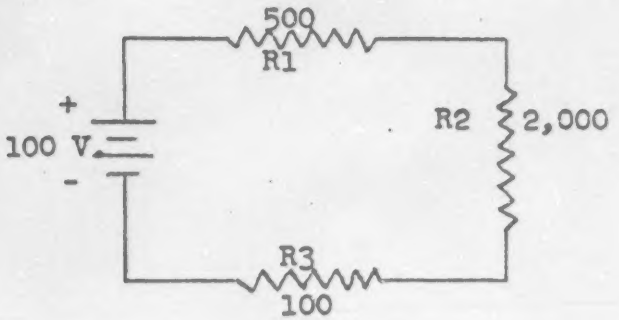
___ a. .44 amperes

___ b. 22.6 amperes

___ c. 44 amperes

___ d. .225 amperes

10. In the following circuit the voltage drop across R3 is:



___ a. 38.4 volts

___ b. 19.2 volts

___ c. 76.8 volts

___ d. 3.84 volts

11. The current flowing through R2 in the circuit in question No. 10 is:

___ a. .2 amperes

___ b. 38.4 milliamperes

___ c. 19.2 milliamperes

___ d. .0384 milliamperes

12. In a circuit with 6 amperes flowing through a 200 ohm resistor we have a power of:

___ a. 7,200 watts

___ b. 1,200 watts

___ c. 120 watts

___ d. 72 watts

13. In figuring the total capacitance of parallel condensers we add the individual capacitors.

___ True ___ False

14. In an inductive field the induced current must always be in the same direction as the applied current.

___ True ___ False

15. In a typical alternating current cycle the current:
    a. reaches maximum at 180 .
    b. reaches mamimum at 90 and 270 .
    c. stays the same through the cycle.
    d. None of the above answers is correct.

T or F 16. When we begin charging a condenser we have very little current flowing at first, but it builds to a large "surge" just before the condenser is charged.

T or F 17. A condenser holds back current flow similar to a resistor so it must consume power.

18. In an inductive circuit the induced voltage is:
    a. in phase with the applied voltage.
    b. in phase with the applied current.
    c. 90 out of phase with the applied voltage.
    d. 90 out of phase with the applied current.

19. If we had an impedence in a circuit and measured the voltage at 100 Volts and the current at 2 Amperes we would find by Ohms Law that the impedence was:
    a. .02 ohms
    b. 20 ohms
    c. 500 ohms
    d. 50 ohms

T or F 20. We can find the primary current of a transformer if we know the secondary current and the turns ratio.

22. The "floating action" of Snap Action thermostats:
    a. eliminates the contact "bounce"on opening.
    b. eliminates "walk" on closing.
    c. widens the thermostat differential.
    d. eliminates contact "bounce" on closing.

T or F 23. A "fine" sandpaper is recommended to clean thermostat contacts.

24. An oversized heating system:
    a. would result in lower heating bills.
    b. may cause a wide temperature differential.
    c. should be installed only in a large house.
    d. should be used if you live in cold climate.

25. Anticipated thermostats are desirable because:
    a. they provide a narrow temperature differential.
    b. they use less electricity.
    c. the heating system will last longer.
    d. they provide a wide temperature differential.

T or F 26. Adjustable anticipator thermostats are more popular because they can match a wide range of primary controls.

T or F 27. If you want a longer cycle on a heating system, the adjustable anticipator should be set to a lower value than the amp. draw of the primary control.

28. For cooling anticipation, the anticipator should be:
    a. in series with the thermostat contacts.
    b. in parallel with the compressor relay coil.
    c. in parallel with the thermostat contacts.
    d. in parallel with the transformer secondary.

T or F 29. When using an anticipated cooling thermostat, current flows through the relay coil only when the compressor is running.

30. As a thermostat bimetal becomes warmer, it will:
    a. open a set of contacts on a cooling thermostat.
    b. close a set of contacts on a cooling thermostat.
    c. close a set of contacts on a heating thermostat.
    d. none of the above is correct.

T or F 31. "System Lag" can be eliminated by changing the thermostat to a lower setting.

T or F 32. The mechanical differential of a thermostat will vary, depending on the type of anticipator used.

T or F 33. On an anticipated heating thermostat, the bimetal temperature will be warmer than room air temperature when the thermostat is calling for heat.

T or F 34. One of the problems with early bimetal thermostats was that they developed too high a contact pressure.

T or F 35. If a millivolt thermostat with anticipator was accidentally connected to a 25 volt system, we would expect the thermostat to cycle rapidly.

T or F 36. Overshoot is found in cooling systems as well as heating systems.

37. Overheating during cold weather is an indication that the thermostat is:
    a. located in the direct air stream of a register
    b. located on an outside wall
    c. near a window where it will be warmed by the sun's rays.
    d. feeling the heat from a nearby lamp.

DEFINITIONS and TERMS

Darken in ALL letters shown.

A	Contact Rating
B	Differential
C	Fixed Differential
D	Bellows
E	Dry Bulb Temp.
AB	Range
AC	Adjustable differential
AD	Set point
AE	Double pole
BC	Single pole
BD	Automatic changeover
BE	Wet bulb temp.
CD	Warp switch
CE	Ambient temperature
ABC	Full load amperes
ABD	Breakpoint
ABE	Single throw
ACD	Double throw
ACE	Automatic recycle
ABCD	Fixed setting
ABCDE	Normally closed

See next page for Definitions

Match the definition with the term.

38. Temperature of the surrounding air in the immediate vicinity of the control body and power element system.

39. A means of changing the difference between the control cut-in and cut-out settings.

40. The change from one function to another, automatically. Otherwise, such changes would be accomplished by manual means.

41. Control contacts return to original position automatically after actuation when the pressure or temperature returns to normal condition.

42. A corrugated metallic diaphragm with a metal cup. Often a complete power unit is referred to as a bellows.

43. Temperature at which all of the refrigerant charge of the element has completely vaporized.

44. The capacity of an electrical contact to handle current and voltage.

45. The difference between the cut-in and cut-out settings of a control.

46. Two single pole contacts operating simultaneously.

47. Contacts make in one direction but break simultaneously in the other direction.

48. The temperature indicated on a dry bulb thermometer. Indicates heat of air and water vapor mixture.

49. The difference between the control cut-in and cut-out setting is factory set and cannot be changed.

50. Provides no convenient means for changing control settings after the control leaves the factory.

51. The amount of current in amperes in an electrical circuit when the load is operating in a full capacity condition.

52. This refers to a switch or a valve which remains closed when the device is not connected to a power supply or is de-energized.

53. The pressure or temperature operating limits of a control.

54. Setting at which the desired control action occurs.

55. One set of two electrical contacts. These two contacts "make" and "Break" on switch action.

56. Contacts "make" or "break" in only one direction of operation.

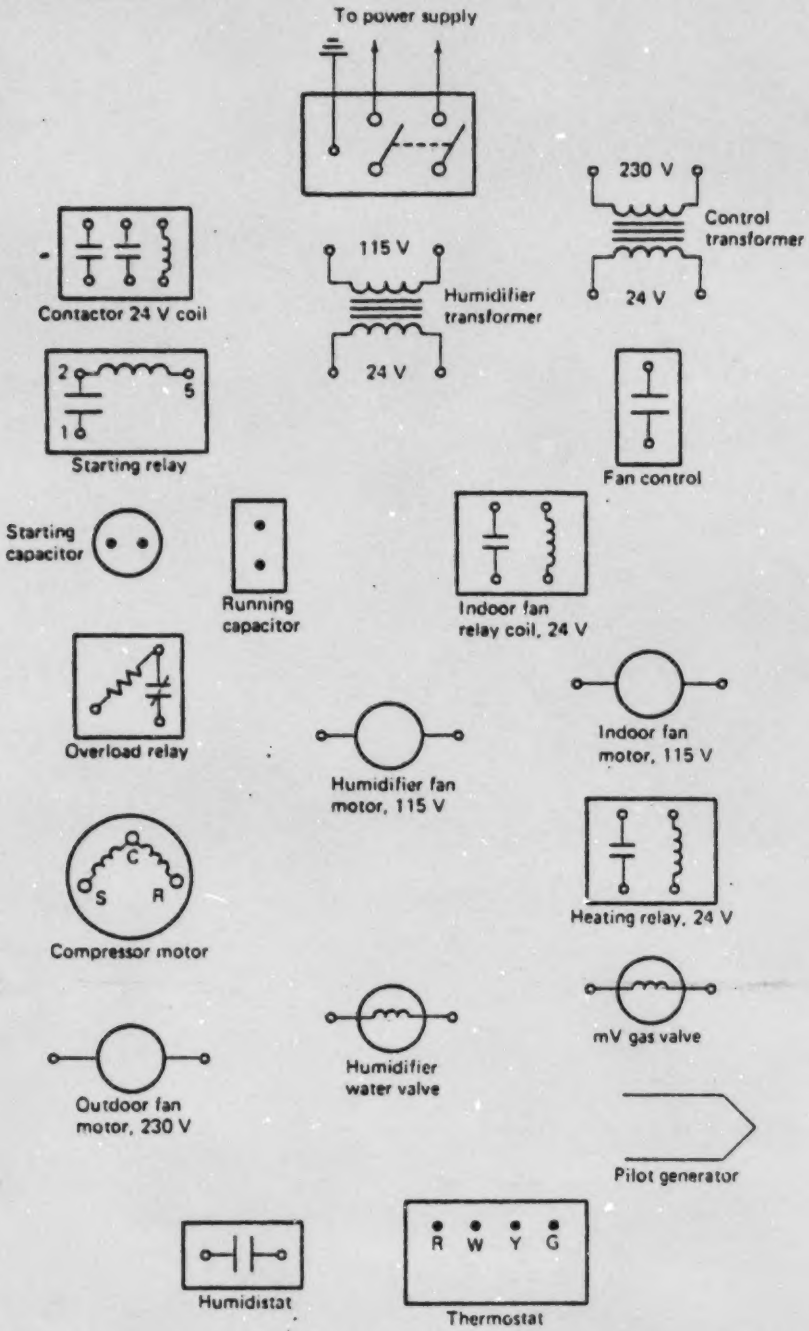
57. A thermal relay switch is actuated by the heating effect of an electric current.

Definitions (Continued)

58. The temperature indicated on a wet bulb thermometer. It indicates the total amount of heat in a mixture of air and water vapor.

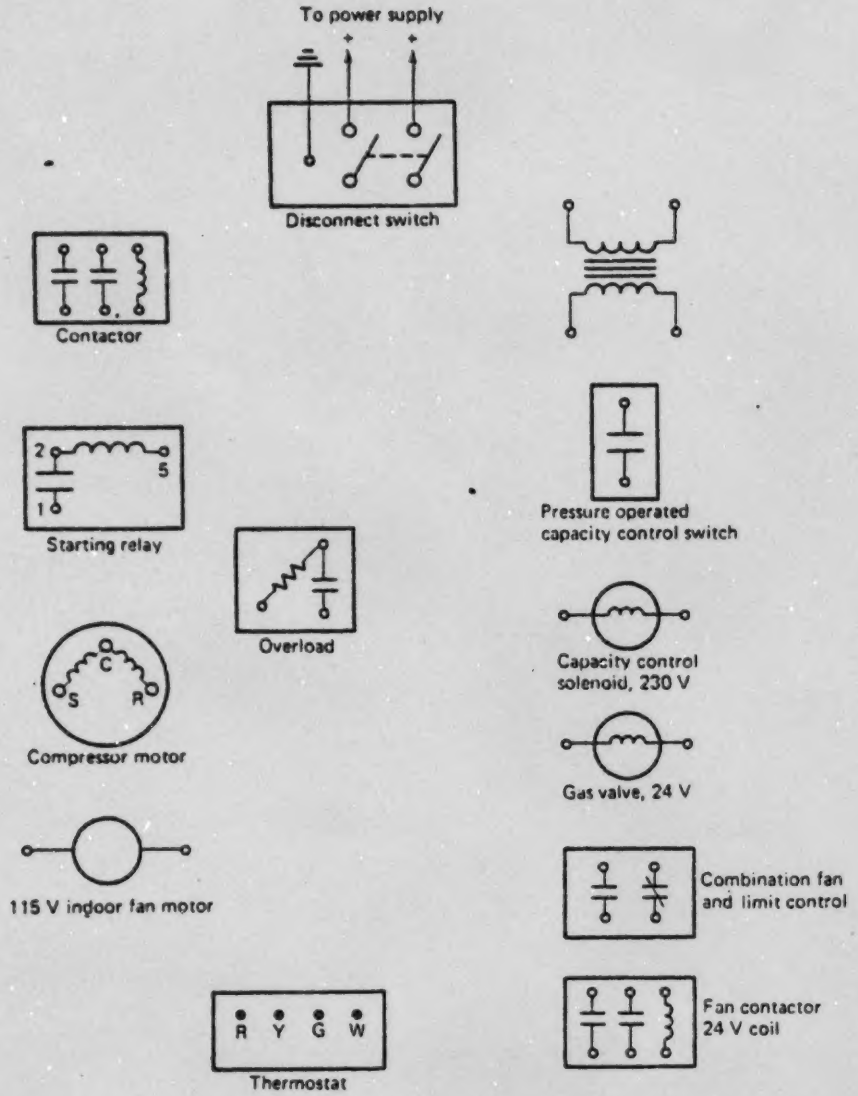
Name_____

DIRECTIONS: Seperate the last two pages of this exam. Draw in correct wiring. Hand in to your instructor.



Complete the above diagram, following the color coding as set before. Do not *mix the voltages.*

Name _____



Complete the above diagram, which includes compressor capacity control.

1. A typical rating for a line voltage thermostat-usually 120 v--. The full load amperage rating is 6.0 amperes. True or False.

2. A typical rating for a line voltage thermostat-usually 120 v-. The locked rotor amps is 60.0 amps. True or false

3. A typical rating for a line voltage thermostat- usually 240. The locked rotor amps is 25.2. True or false

4. The switch rating at 25 volts AC is 1.5 amperes for the heating and cooling switches. T or F
5. The anticipators in the heating circuit for both stages of heating are rated at a maximum of 1.2 amperes. T or F
6. In the cooling circuit, the anticipator in the first stage cooling cycle has a resistance of 5,100 ohms. T or F

7. The anticipator in the second stage of cooling has a resistance of 10,000ohm T or F
8. Electric room thermostats may be divided into three categories: a.line voltag b Millivoltage c low voltage T or F
9. Name two advantages of line voltage thermostats
   a. _____ b._____

10. Name two disadvantages of having line voltage thermostats
    a._____ b _____

11. A thermostat can control the temperature of a conditioned space or a process. T or F
12. Line voltage thermostats maintain the same close control of temperature as do low voltage (24V) thermostats. T or F
13. Anticipation is tha addition of heat to thermostat contacts. T or F.

14. The heating cut-in point may be the same as the thermostat temperature setting. T or F.
15. First and second stage cut-in points on both heating and cooling are interlocked. T or F.
16. The addition of artificial heat to the bimetal (increases-decreases) the differential of the thermostat.

17. A complete heating cycle is the total of the _____ heating cycle and the _____ heating cycle.

18. If an installation has two transformers in separate circuits, they need not be phased. T or F
19. A modutrol motor will operate through _____ degrees.
20. Step controllers should hold a temperature rise of _____ degrees.

21. The resistances are equal on both sides of the modutrol unit (circuit) when R1 = _____ and R2= _____

22. Referring to your economizer section.
    With the thermostat calling for cooling and the outdoor ambient below the outdoor air thermostat setting, the circuit is complete to what load ?
    a._____
23. Name the four loads in the economizer circuit: a._____B._____
    c._____ d._____
24. The components that do the mechanical work of keeping the system in balance are a._____b._____

25. On a drop in outdoor temperature,(more resistance-more current)passes thru the left leg to the (lower- upper CBR) that will close(cw- ccw switch)

26. Suppose cooling thermostat is satisfied, what load is first energized? _____

27. If the fan is on continuously with no call for cooling, what loads are energized ? a.-_____ b._____

28. Referring to your (low voltage cooling control circuit). Heat Pump. On a call for cooling, the TCo contacts close, what load is energized ? _____

29. As contacts TC1 close, a circuit is completed through the _____ to energize the _____ and start the _____.

30. Another circuitthru TC1 contacts and the _____ _____ _____switch energizes the _____ _____.

31. When the contactor coil contacts close, what circuits are completed ? a._____ b._____ c._____

32. To energize the DFR coil what two switches must close? a._____ b._____

33. If during the defrost cycle, the defrost thermostat fails to open, the _____ _____ contacts will open and return unit to the heating cycle.

34. Closing the emergency heat switch bypasses the _____ _____, locks out the _____ and brings on the _____ _____.

35. How are most defrost cycles initiated? _____ _____

36. What is the simplest type of defrost system ?_____

37. What fan or fans are turned off during defrosting ? _____ _____

38. What control is used to terminate the defrost cycle ?_____

39. ~~XMM~~ How are the HPS and the LPS hooked-up in the circuit ? (Series- parallel)

40. Before the humidifier fan operates the _____ _____ _____ must operate first.(that is energized first)

41. Airstats are mounted in the _____ air plenum.

42. Humidistatats may be used either on~~XXXXXXX~~ _____ or _____voltage.

43. REFERRING TO HEATING_FIRST STAGE REVERSE CYCLE ONLY.AND SECOND STAGE. When TH1 thermostat closes, what two circuits are completed ? a. _____ b. _____

44. What unit is providing heat at this time? _____

45. If the temperature in the conditioned space would continue to drop, _____ contacts would close and energize _____.

46. Energizing sequencer 1, closes a a set of contacts after a delay of about _____ sec.

47. Name the three components that complete the time Guard circuit. a._____ b._____ c._____

48. What two important tasks are accomplished by the use of the Time Guard ? a._____ b._____

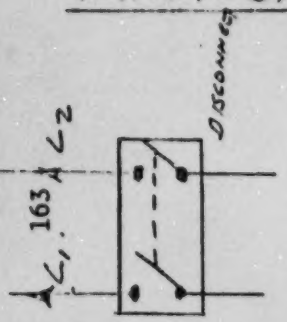
49. When contactor relay coil is energized, what switch or contacts close _____ and what loads are energized ? _____ _____

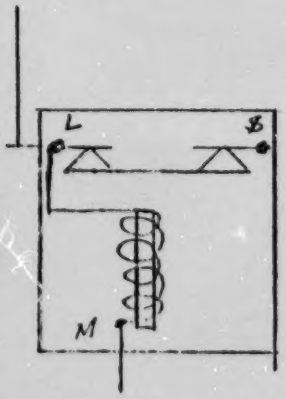
50. After about _____ sec, what unit is now energized ?_____

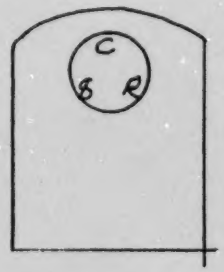
1

PART-ONE

WIRE COMPRESSOR WITH CURRENT RELAY, START CAPACITOR, AND 2-TERMINAL OVERLOAD.



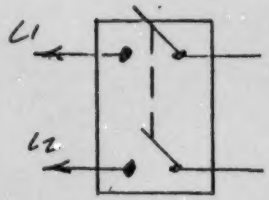


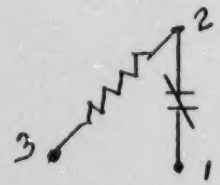


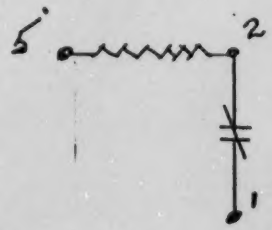
199

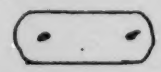
PART-TWO

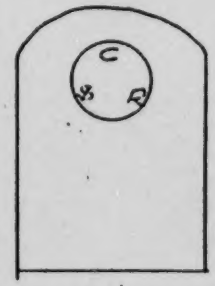
COMPRESSOR WITH POTENTIAL RELAY, START AND RUN CAPACITORS AND 3-TERMINAL OVERLOAD.









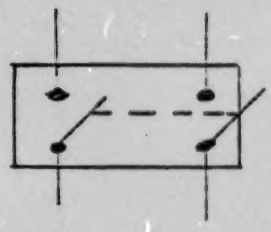


200

NAME _____

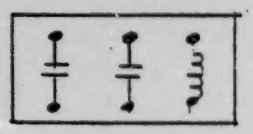
NAME _____

NAME _____

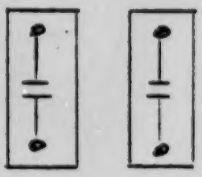


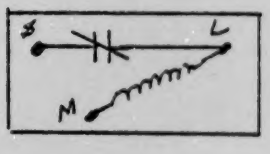
DISCONNECT SWITCH

CONTACTOR

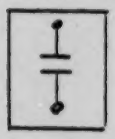


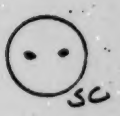
HIGH-LOW PRESSURE SWITCHES



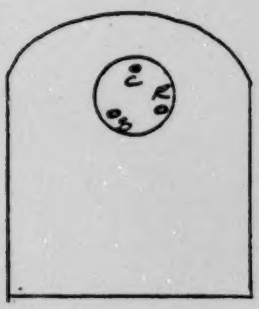


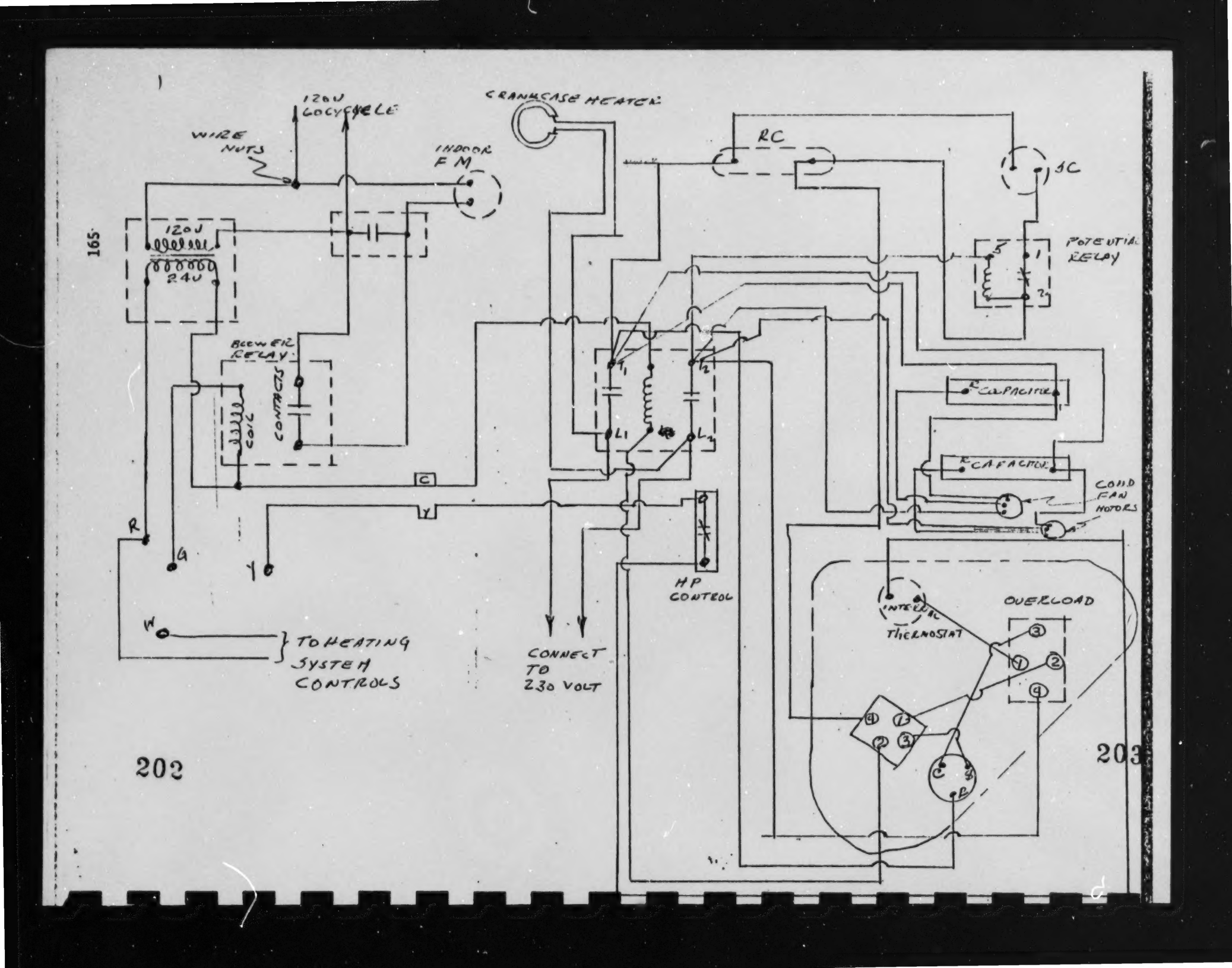
COLD CONTROL THERMOSTAT





LIQUID LINE SOLENOID VALVE




165
120V 60CYCLE
WIRE NUTS
CRANKCASE HEATER
INDOOR F M
RC
1C
120V
24V
POTENTIAL RELAY
BLOWER RELAY
CONTACTS
COIL
CAPACITOR
CAPACITOR
COND FAN MOTORS
R
G
Y
W
C
HP CONTROL
INTERNAL THERMOSTAT
OVERLOAD
TO HEATING SYSTEM CONTROLS
CONNECT TO 230 VOLT
202
203

AREA - HVACS ELECTRICAL

Unit 15 - Advanced Controls

I. Instructional Objectives
The student will learn the fundamentals and receive a solid background in the area of sophisticated commerical controls, i.e., modulating electric and pneumatic control systems, solid state protection and sequencing controls.

II. Reference Materials
Control Systems for Heating, Ventilating and Air Conditioning, Haines (all)
RETA Control Theory and Fundamentals, Part II
Understanding Solid State Electronics
Fundamentals of Pneumatic Controls
Electric Modulating Controls - Honeywell
RA890 Service Handbook - Honeywell
Fireye Flame Safeguard Bulletins

III. Visual Aids
Overheads made from above texts
Honeywell Pneumatic Slides
Honeywell Slides, RA890

IV. Method Performance Conditions
Given modulating motors, linkages, and dampers, RA890 and Fireye controllers with test units and equipment to apply controls to. Pneumatic controls and board to develop pneumatic system on. Solid state brown and blackout and safety controllers.

V. Outline

1. Modulating control circuit application
2. Modulating control circuit operation
3. Modulating controllers
   A. Room thermostats
   B. Remote bulb temperature controllers
   C. Pressure controllers
4. Modulating motors
   A. Reversible capacitor motor
   B. Balancing relay

C. Feedback

D. Potentiometer

E. Gear train

F. Installation

G. Troubleshooting procedures

H. Valves

I. Dampers and linkages

J. Installation and adjustment

5. Pneumatic control systems

A. System operation

B. Measured variable

C. Controlled variable

D. Control agent

E. Controlled devices

6. Controllers

A. Controller feedback

B. Measuring element

C. Supply pressure

7. Control modes

A. Two-position

B. Proportional

C. Proportional plus reset

8. Applications of pneumatic controls

9. Solid State

A. How circuits make decisions

B. Semiconductors

C. Diodes

D. Transistors

E. Thyresistors and optoelectronics

F. Digital integrated circuits

VI. Student Evaluation Parameters

Student will demonstrate an ability to install, troubleshoot, adjust all types of modulating controls and their linkages. All types of sequencing safety controls will be troubleshot, installed and cross-referenced. Students will install all types of pneumatic components, understanding how to troubleshoot and repair. Student will trouble shoot and learn how to replace solid state sensors and devices used in the HVACS field.

VII. Sequence of Instruction

1. Read all reference material.
2. View all visual aids
3. Discuss operation of all components in class using outside manufacturers representatives.
4. Perform lab projects.
5. Take unit tests.

Name _____

T or F 1. The wording double pole double throw relay, indicates that the relay has four sets of contacts.

2. When testing a series 90 damper motor, what tools will be needed? (Circle any that apply)

a. 135 ohm potentiometer.

b. Volt meter.

c. Ohm meter.

d. Milliampmeter.

e. Screwdriver.

T or F 3. There are three types of series 90 damper motors. a)Two position, b)Dead stop, and c)Modulating.

4. A modulating type motor consists of? (Circle all that apply)

a. A reversible motor.

b. Balancing relay.

c. Feed back potentiometer.

d. Gear train.

T or F 5. The balancing relay in a modulating motor controls it.

T or F 6. The modulating motor is equipped with switches that limit its rotation to 90 or 160 degrees?

TorF 7. The gear train must be greased three times a year on the motor.

TorF 8. A balancing relay has a single pole double throw set of contacts

TorF 9. A change in magnetic flux from one coil to the other causes the balancing relay contacts to move.

TorF 10. There are three separate circuits in the modulating motor.
a) Motor circuit b) Balancing circuit c) Control circuit.

TorF 11. The R terminal on the potentiometer is connected directly to the W terminal of the motor.

12. When refering to the motors torque, we mean- (Circle one)
a. The force available to do the work.
b. Inch pounds at input shaft.
c. Output shaft circumference in turns.

TorF 13. When sizing a transformer to operate the damper motor we are concerned with its AV rating.

TorF 14. When locating a damper motor we must consider ambient temperatures , not over 200° or below -15°.

TorF 15. It is important to mount a modulating motor on a surface free of vibration.

16. When trouble shooting the motor,(check all items that should be gone over)
a. Motor responds properly to controller.
b. Operation is smooth and quiet.
c. Motor completes entire stroke in approx. time rated for.
d. Crack in case.
e. Voltage drop through motor windings.

17. What are the two types of damper action. _____blade action, _____blade action.

18. What is the minimum that the motor shaft and damper shaft can be apart, for proper linkage operation _____".

TorF 19. It is important to try stalling the motor to see if end switches work.

TorF 20. The crank arm is sold separately from the damper motor itself.

21. When setting linkage, the ball joint on the crank arm should be at the _____ end, of the arm.

22. The motor should be in a _____ position when adjusting linkage with the adjusting guide card.

TorF 23. The ball joint on the damper crank arm is positioned according to the desired degrees of damper opening.

24. If the motor and damper crank arms are on the same side of their respective shafts, the shafts will turn in the _____ direction.

25. An economizer control package, attached to a modulating motor, drives the motor according to five different sensing elements. (Circle three that pertain)

a. Mixed air controller.

b. Exchanger air temp.

c. Changeover controller.

d. Minimum position potentiometer.

e. End switches.

f. Econo heat riser.

26. At the RSES metting on April 4th. Mr Lyle Poole from Commonwealth Edison spoke-

T or F a. He stated that the solar collectors are an inexspensive way to generate more electricity.

26(cont.)

orF b. He stated that using a heat pump for existing house replacement heating, is out of the question.

or F c. He stated you must have Com.Eds. certification to work on heat pumps.

or F d. Any reputable servise man can buy heat pump parts.

or F e. He stated Com.Ed. will have no problem generating enough power to get through another winter like that of 1977.

or F 27. The honeywell RA890 is designed to perform two basic switching functions, through the use of two relays.

or F 28. The RA890 has a load relay that responds to a call for fan.

or F 29. The RA890 has a flame relay that responds to a flame signal.

or F 30. An RA890E model uses a vacuum tube that should be replaced once a season.

or F 31. If a standing pilot is to be used with the RA890E model, it must have a wire loop cut and the F model which is solid state must have a screw removed.

or F 32. A special W136A meter is helpful in reading a fluxuating flame responce.

33. Below are listed all the steps that the RA890 goes through. (Put them in proper sequence by numbering them) 1-12

33(cont.)

____ Flame proved- flame relay pulls in.

____ Call for heat- load relay pulls in (Flame relay must be out) ignition starts.

____ Control powered- low voltage controller- flame relay pulls in and immediately drops out.

____ Pilot valve or burner motor powered.

____ Flame relay drops out.

____ Safety switch heats.

____ Safety switch heater deenergizes.

____ Ignition cuts off (if wired for interrupted ignition)

____ Fuel valve closes.

____ Main valve powered.

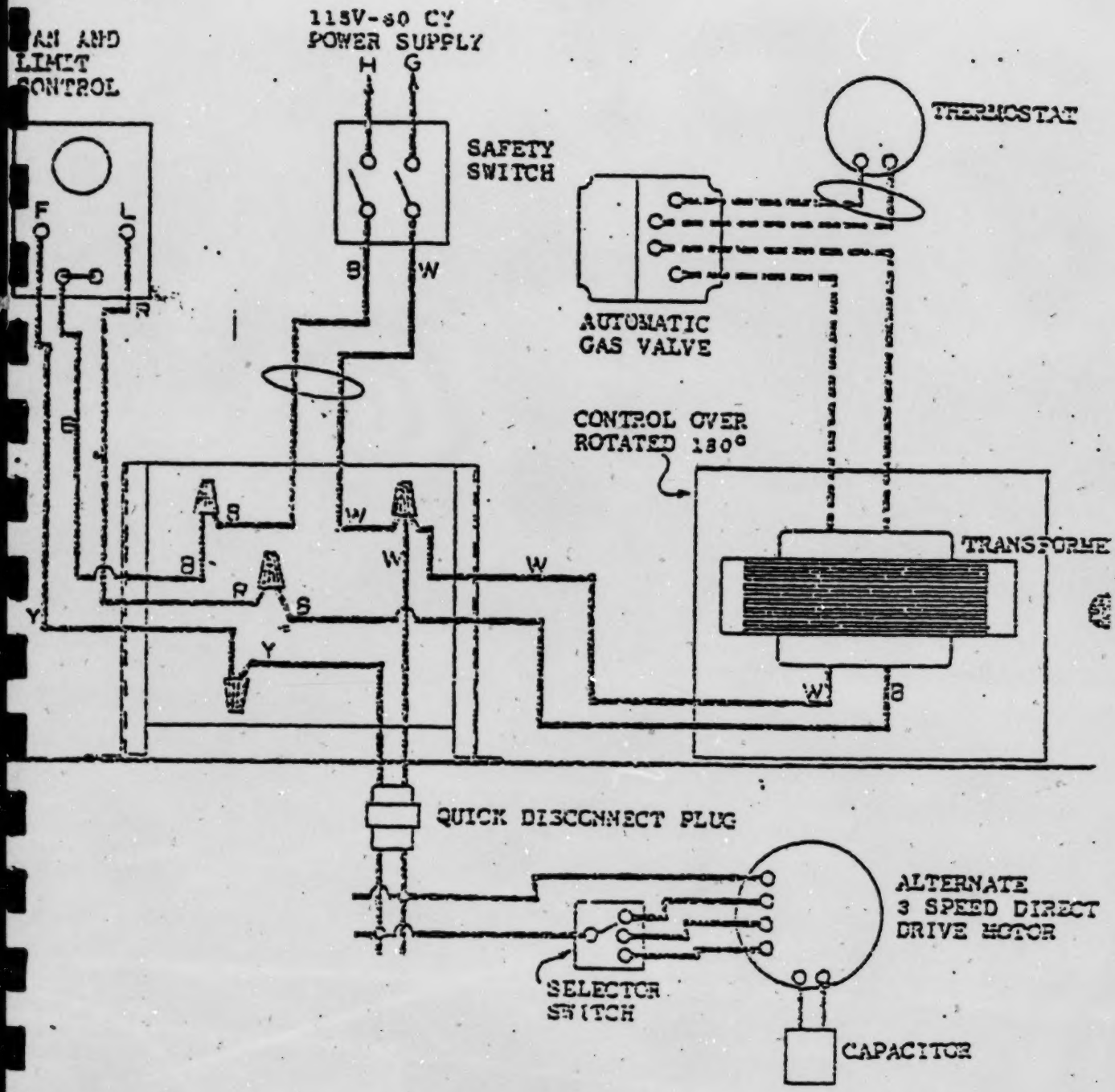
____ Burner motor stops.

____ Call for heat satisfied- load relay drops out.

T or F 34. A flame response reading of at least five is required for proper operation.

T or F 35. The honeywell FSP1535 test panal,as demonstrated in in class, is a necessary item for any serviceman checking RA890 units.

36. Give a pictorial representation of a DPDT relay. Wire it into the furnace diagram pictured on the foàlowing page. Remove the fan selector switch, and use the DPDT relay in its place. Connect two speeds of the fan, low for heat and high for cool. Also add a humidifier, and electronic air cleaner using relay.


AN AND
LIMIT
CONTROL
115V-60 CY
POWER SUPPLY
H
G
SAFETY
SWITCH
THERMOSTAT
AUTOMATIC
GAS VALVE
CONTROL OVER
ROTATED 180°
TRANSFORME
QUICK DISCONNECT PLUG
ALTERNATE
3 SPEED DIRECT
DRIVE MOTOR
SELECTOR
SWITCH
CAPACITOR

T or F 1. There are 5 basic parts of a series 90 modulating motor.

T or F 2. The controlling potentiometer is a variable resistor.

3. There are two separate circuits in the modulating motor powered from T1 and T2.
   A. Relay circuit
   B. Control circuit
   C. Motor circuit
   D. None of the above

4. When testing a series 90 damper motor, what tools will be needed?
   A. 135 ohm potentiometer
   B. Volt meter
   C. Ohm meter
   D. Milliammeter
   E. Screwdriver

T or F 5. The modulating motor is equipped with switches that limit its rotation to 90 or 160 degrees.

T or F 6. The gear train must be greased once a year.

T or F 7. A balancing relay has a single pole double throw set of contacts.

T or F 8. A change in magnetic flux from one coil to the other causes the balancing relay contacts to move.

T or F 9. When sizing a transformer to operate a dmaper motor you are concerned with its AV rating.

T or F 10. When locating a damper motor we must consider ambient temperatures between 200° and -15°.

11. When trouble-shooting the motor you should check which items?
   A. Motor responds properly to controller.
   B. Operation is smooth and quiet.
   C. Voltage drop across motor windings.
   D. Motor completes entire stroke in rated time.
   E. All of the above.

12. What are the two types of damper action?
   A. Parallel action
   B. Direct action
   C. Opposed action
   D. None of the above

13. What is the minimum distance that the motor shaft and the damper shaft can be apart, for proper linkage operation?
   A. 8"
   B. 12"
   C. 24"
   D. There is no minimum
   E. None of the above

14. The control circuit in a series 90 motor consists of:
    A. Controlling Potentiometer
    B. Balancing relay controls
    C. Feedback potentiometer
    D. None of the above
    E. All of the above

T or F 15. Electromechanical controllers can sense temperature only.

T or F 16. TIMING - is the time required for the motor to run through its stroke.

T or F 17. It is important to stall the motor to see if the end switches work.

T or F 18. The ball joint should be at the outer end of the motor crank arm, when setting linkage.

T or F 19. The series 90 damper motor is weather-proofed at the factory.

T or F 20. It is important that the changeover control on the economizer be set to sense return air only.

T or F 21. It is important to mount a modulating motor on a surface, free of vibration.

T or F 22. A limit controller prevents a condition from exceeding a predetermined level.

23. Shorting terminals W to R causes the motor to _____.
    A. Open
    B. Close
    C. Will not move motor

T or F 24. The economizer regulates the relative amounts of outdoor and return air used to assure maximum use of outside air for free cooling.

T or F 25. The Honeywell RA890 is designed to perform two basic switching functions through the use of two relays.

T or F 26. The RA890 has a load relay that responds to a call for fan.

T or F 27. The RA890 has a flame relay that responds to a flame signal.

T or F 28. An RA890 E uses a vacuum tube that should be replaced once a season.

T or F 29. A W136A meter is helpful in reading a fluxuating flame response.

T or F 30. If a standing pilot is to be used with the RA890 E, it must have a wire loop cut, and the F model which is solid state must have a screw removed.

T or F 31. A flame response reading of at least five milliamps is required for proper operation.

T or F 32. The flame simulator is used to see if the load relay pulls in when a flame is present.

33. What is the vacuum tube's purpose in the RA890 E?
A. To create a suction on the flame.
B. To create a holding circuit.
C. To create service calls.
D. None of the above.
E. All of the above.

MATCH THE FOLLOWING:

34. Terminal 2	A. Pilot or burner motor
35. Terminal 3	B. Main gas
36. Terminal 4	C. Hot line
37. Terminal 5	D. Ground
38. Terminal 1 and 6	E. Interrupted ignition

T or F 39. A low voltage controller is all that can be used in the RA890 G.

40. What type of reset does the RA890 use?
A. Automatic
B. Double set back
C. Manual
D. All of the above

T or F 41. "T-T" terminals are used for the line voltage controller.

T or F 42. The flame simulator circuit is line voltage.

43. What causes the load relay on a RA890 F to pull in, after a <u>delay</u> on a call for heat.
A. Thermistor
B. Vacuum tube
C. Transistor
D. None of the above

44. There are three types of flame detection used with RA890's.
A. Cadmium cell
B. Photocell
C. Flame Rod
D. Ultra Violet
E. All of the above

T or F 45. The RA890 is used in residential oil burners.

46. Below are listed all the steps that the RA890 goes through. Put them in proper sequence by numbering them.

_____ Flame proved-flame relay pulls in.

_____ Call for heat-load relay pulls in, ignition starts.

_____ Control powered-low voltage controller flame relay pulls in and immediatly drops out.

_____ Pilot valve or burner motor powered.

_____ Flame relay drops out.

_____ Safety switch heats.

_____ Ignition cuts off (if wired for interrupted ignition)

_____ Fuel valve closes.

_____ Main valve powered.

_____ Burner motor stops.

_____ Call for heat satisfied - load relay drops out.

Name_____

Unit 15 - Final Examination

T or F 1. Automatic controls can be used whenever a variable condition must be controlled.

T or F 2. Automatic control is the automatic maintenance of a balanced state within a process.

T or F 3. The feed-back and closed loop system are both a method of control systems.

T or F 4. A controlled variable is the quantity or condition which is measured or controlled medium.

T or F 5. The controller does not control the process, the process controls itself through use of a closed loop.

T or F 6. Controlled variables normally of interest are temperature, pressure and humidity.

T or F 7. Temperature is of the most importance.

T or F 8. Humidity is a controlled variable.

T or F 9. Pressure conditions can influence operation of equipment.

T or F 10. If the measuring means is slow in responding to change, the controller will be unable to provide proper counter-action.

_____ 11. Typical sensing elements for temperature are: (choose any that apply)
a. bimetals
b. bellows
c. remote bulb
d. rod and tubes
e. resistance wires

T or F 12. Bimetal sensing elements are made of invariables and brass.

_____ 13. Bimetal is used in many shapes for sensing. (pick any that apply)
a. U-shape
b. helical shape
c. spiral shape
d. none of the above

T or F 14. A sealed bellows is a common type of primary sensing element.

T or F 15. A remote bulb uses either a cross ambient, high temperature or low temperature fill.

T or F 16. Rod and tube primary sensing elements are used with pneumatic insertion controllers.

T or F 17. Human hair is used for humidity sensors.

T or F 18. The electronic humidity controller uses gold leaf in its grid.

_____ 19. Humidity sensing elements can be made of: (choose any that apply)
a. wood
b. leather
c. nylon
d. graphite
e. ceramic

MATCH THE NUMBERED QUESTIONS(20-24) WITH A LETTER ANSWER.

_____	20.	An actuator is	a. the difference between the actual control point and set point at any instant of time
_____	21.	The set point is	b. the valve at which a controller is set, represents the desired valve
_____	22.	The control point is	c. a power unit
			d. the actual valve of the controlled variable
_____	23.	Deviation is	e. the sustained deviation between the actual control point and the set point under stable conditions.
_____	24.	Offset is	

T or F 25. The electric control uses line or low voltage as its energy source.

T or F 26. A potentiometer sets up a varying resistance in an established circuit.

T or F 27. Pneumatic controlled systems use 15 to 25psig of compressed air as a source of energy.

T or F 28. Air is supplied to the controller which in turn regulates the air pressure delivered to the final pneumatic controlled device.

T or F 29. An electronic control system employs an electronic amplifier to increase is signal to the final control devices.

T or F 30. Combination electronic-pneumatic systems utilize compressed air for operation of final control device.

MATCH THE FOLLOWING NUMBERED QUESTIONS (31-35) OF MODES OF CONTROL ACTION WITH AN EXAMPLE OR DEFINITION.

_____	31.	Simple two position	a. low voltage thermostat with built-in heat anticipato
			b. Thermostat switching power to a unit heater fan
_____	32.	Timed two position	c. Two valves of the controlled variable which determine the position of the final control
_____	33.	Floating control	d. Measurement of suction pressure in a refrigeration machine to control loading and unloading
_____	34.	Proportional mode	e. The final control element assumes a position directl proportional to the deviation of the control point from set point.
_____	35.	Two position	

The following questions will be on pneumatics.

T or F 36. Air is supplied by a compressor which need little or no maintenance.

T or F 37. The receiver tank normally holds about 100 psi of air.

T or F 38. Pressure is dropped in control lines by means of a regulator.

T or F 39. Air lines are run in copper or polyethylene tubings varying in size from 1/8" to 2".

T or F 40. A refrigerated dryer should be used to drop moisture levels in control air.

T or F 41. An oil removeal filter is also used.

T or F 42. A 30 psi relief valve is used on the main airline.

T or F 43. The main air line feeds the room thermostat.

T or F 44. A single pressure thermostat is one that operates from constant main air pressure of 15-25 psi.

PUT THE FOLLOWING IN ORDER. PUT A LETTER FOR EACH NUMBER IN THE ORDER IN WHICH THEY SHOULD BE CARRIED OUT. THE FOLLOWING STEPS ARE USED TO CALIBRATE A SINGLE PRESSURE THERMOSTAT.

____ 45.

____ 46.

____ 47.

____ 48.

____ 49.

____ 50.

a. Check main air pressure, make sure it is between 15-25 psi
b. Make sure the main air line is hooked up to the thermostat and branch line connected to the actuator.
c. Change the set point indicator to the ambient temperature measured using the special calibration wrench.
d. Attach the required gauge tap fitting to the gauge port on the thermostat.
e. Using an accurate thermometer, measure ambient temperature at the thermostat, Do not touch the bimetal or get hands close.
ab. Turn the calibration screw until the branch line pressure reads 9 psi. (or mid-point of the spring range for actuator)

AREA - BACK UP HEATING SYSTEMS

Unit 16 - Gas Heating

I. Instructional Objective

To instruct the student in the use of gas as a fuel for domestic and commercial heating. To inform the student in the use of various tools used in servicing heating units. Instruction in sequence of operation of each type of gas heating system, controls, safeties. Instruction in seasonal service and maintenance required. Show student proper diagnosing and repair of the systems. Instruct in use as back up secondary for solar heating.

II. Reference Materials

Fundamentals of Gas Combustion - all
Comfort Heating, 1, 2, 3, 5, 6, 11, 14
Carrier GTA Gas Heating
Honeywell Gas Controls

III. Visual Aids

Carrier slides GTA 5-101
Honeywell, Gas Controls Overheads
Components of Gas Systems

IV. Method Performance Conditions

Given several types of gas furnaces, conversion burners, boilers and forced air, electronic ignition, flue dampers, control systems, combustion analyzer kits, all necessary test equipment.

V. Outline

1. Types and history of gas combustion
2. Types of gas fired furnaces and burners
   A. Location of parts
3. Safeties used in residential gas fired equipment
4. Control systems used in residential gas fired equipment
5. Setting BTU input
6. Annual service
7. Problem diagnosis
   A. Electrical
   B. Mechanical

8. Safeties in commercial burners

9. Problem diagnosis - commercial

VI. Student Evaluation Parameters

Student will demonstrate all safety procedures while installing, servicing, and maintaining gas equipment. Student will install and service gas furnaces, forced air and boilers, electronic ignitions, flue dampers. Student will service and analyze systems with cleaning vacuum, combustion analyzer, thermometers, monometers, stop watch, baso kit, Honeywell analyzer, RA890 tester and Fireye. Student will be capable of servicing and installing all makes and models of gas heating equipment.

VII. Sequence of Instruction

1. Read all reference materials.

2. View all visual aids.

3. Discuss all safety and operational functions of gas heating.

4. Student will perform installations, and servicing in lab.

5. Take Unit tests.

Unit 16 - Sample Lab #1

Objective: To familiarize the student with pilot and main burner assemblies, their cleaning, disassembly and reassembly.

Tools Needed: Tool box
Gas furnace, or conversion burner
Commercial boiler

Procedure: Completely remove and disassemble pilot assembly. Clean same and replace. Remove and clean main burners - reassemble. Do this on one conversion burner, one commercial unit (either roof top Chrysler unit or American Standard or Red Boiler).

Write up your procedure for cleaning these components on each unit. Hand in to lab instructor.

If you finish early, draw up a pictorial of the gas train on the commercial boiler.

Unit 16 - Sample Lab #2

Objective: To familiarize student with gas pressures and how to measure them with slack tube manometer and gauge manometer.

Materials Needed:
Allen Wrench
Slack tube manometer
Gauge manometer
Tool box

Project Procedure:

1. Use conversion burners on tables. Turn gas on and light pilots. Check for any leaks and check for power.
2. Fill manometer to mid-point, remove all air bubbles.
3. Hook up manometer to tap on side of gas valve. Level and zero.
4. Fire unit and take pressure readings. Adjust pressure to 3½". Try adjusting lower and higher. Check how flame reacts.
5. Write up how each manometer was hooked up and tell how you adjusted pressure. Put on BACK of this sheet and hand in.
6. Now hook up to real furnaces. No one is to leave lab early.

Unit 16 - Sample Lab #3

Objective: Actively involve student in proper furnace cleaning and check out procedures.

Tools Needed:
- Tool Box
- Vacuum Cleaner
- Rags
- Furnace Cleaning Brush
- Slack tube Monometel
- Stop Watch
- Thermometer
- Furnace

Procedure:

1. Turn furnace on and check to see if it works; if it does turn off at main switch.
2. Remove necessary burners, etc. enabling you to visually check heat exchanger for cracks or leaks.
   Note: If a conversion unit in a sealed heat exchanger - (smoke bombs may be used)
   If no cracks or leaks are apparent proceed to step three.
   If a crack is found inform owner of danger and need for replacement of exchanger before continuing cleaning.
3. Pull all burners, diverter, baffels out of exchanger and brush out and vacuum out same.
4. Make sure all heat exchanger passages are clear.
5. Make sure all burners are clean and open, including pilot burner
6. Reassemble and check thermocoupler assembly with meter, both thermocoupler and power assembly.
7. Check smoke pipe to chimney for dirt and corrosion
8. Check chimney for any debris; make sure it is clear and has a good draft.
9. Pull blower assembly and check squirrel cage for dirt build up in vains. If direct drive check motor for dirt buildup. Oil motor and bearings. If belt drive check bearings, pulley alignment belt. Re-install unit.
10. Check gas pressure to unit with monometel
11. Light pilot and fire main burners.
12. Clock meter and check input.
13. Check heat rise across unit according to name plate. Set blower speed accordingly.
14. Check fan and limit control operation.
15. Check calibration of thermostat.
16. We will go into combustion efficiency next.

Name_____

Unit 16 - Quiz #1

1. Is gas heating the most popular of modern fuel heating systems?

   Yes or No

2. It wasn't until the 1950's that natural gas pipe lines brought gas to most large cities. True or False

3. Natural gases are the lightest of all petroleum products.
   True or False

4. Gas pressure to most furnace manifolds is cut to eight inches of water column. This is done by the furnace regulator.
   True or False

5. Orfices are openings through which gas is admitted to the main burner.
   True or False

6. Most furnaces use one of these four different types of main gas burners. Drilled, slotted, ribbon, inshot.
   True or False

7. What are the two items that can be tested with a baso meter on a gas furnace? Exsplain how it is used?

8. How many millivolts should a good thermocouler produce?

9. What is a thermopile? How many millivolts should a thermopile produce.

10. Is there such a thing as a bimetal pilot? yes or no

11. A thermocoupler is made up of two pieces of similar metal.

True or False

12. How far should a chimney extend past the high point of a roof?

13. Should the vent pipe extend four to six inches into the chimney chamber? yes or no

14. If the same chimney is used for a hot water heater and a furnace flue pipe. Where should the hot water heater flue enter the chimney above or below the furnace flue?

15. Is combustion air in a closed closet adequate to operate a atmospheric gas furnace? yes or no

16. How many feet can you run a vent pipe before you should start enlarging its size.

17. All flue pipes should slope upwards toward the chimney at least one inch per every three foot section. True or False

18. When converting a furnace from gal to gas it is possible to use the original nozzle size off the old oil burner to size the gas input.
True or False

19. The formula for clocking a gas meter to get Btu/Hr is

$$\frac{3600 \text{ Sec/hr} \times \text{gas pressure}}{\text{time in seconds}}$$

True or False

20. When efficiency testing a gas furnace we need: (circle any that apply)
    1. gas pressure manometer
    2. stop watch
    3. air temp thermometer
    4. draft gauge
    5. flue temp thermometer
    6. CO_2 analyzer

21. What is a good CO2 range for gas _____ through _____.

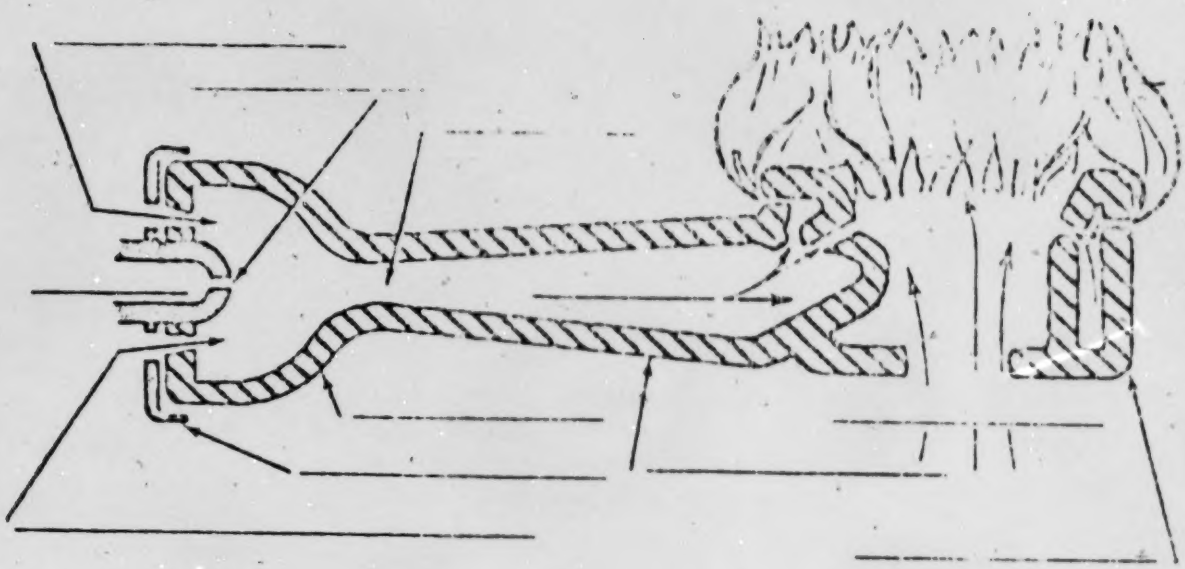
22. What is a good stack temperature?

23. What reading does a monometer give you? Explain its use.

24. What two figures are used to operate a gas service calculator?

25. Fill in the blanks in the following diagram with the words listed:

Orifice	Throat
Primary Air	Mixing Tube
Burner Head	Secondary Air
Mixing Head	Gas
Air Shutter	Gas & Air



26 Mixing tubes of the shape in the preceding diagram are often called _____ tubes.

27 What type of flame should you expect normally from the burner diagrammed in 9, above? _____

_____

28 What kind of flame would you expect in the following cases? How would you fix it?

Condition	Flame
A. Dust ball in mixing tube	_____
B. Partially clogged orifice	_____
C. Air shutter wide open (list two)	_____
	_____
D. High gas pressure	_____

29 Almost all burners used in domestic heating appliances are enclosed by a _____ (two words).

5

30 State briefly the principle of a thermocouple: _____

_____

_____

_____

31 The voltage generated by a thermocouple depends on the _____ _____ between the hot and cold junctions.

32 A thermopile is a _____

33 Failure of the thermocouple is usually due to _____

_____

34 What is the advantage of increasing the cross sectional area of a thermocouple? _____

_____

35 When installing a thermocouple you should remember two things:

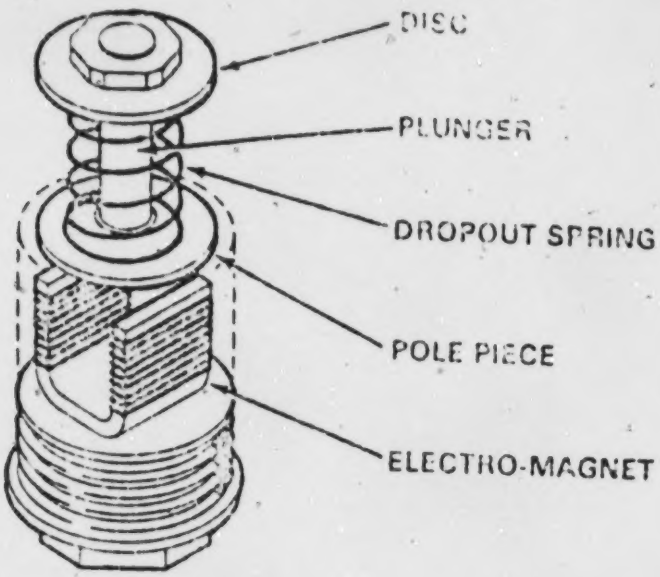
a. The thermocouple connection is an electrical connection and you should not use _____

b. The thermocouple lead should not be bent within _____ of either end.

36 The leadwire length of a millivoltage system is strictly limited as to total length because the circuit _____ must not reduce the _____ below the operating level for the system. If the length of thermostat cable is excessive, its _____ may prevent the _____ from opening.

37 What millivoltage output is required on a Powerpile system with a wall mounted thermostat? _____

38 Complete the following summary of power unit OPERATION by referring to the figure below.



The millivoltage output of the thermocouple or thermopile energizes the _____. This power is not sufficient to pull the spring loaded _____ assembly into contact with the magnet . . . it must be manually "reset". Once the plunger is reset, with a normal pilot flame and good thermocouple or _____, the electromagnetic holding force exceeds that of the _____ and the plunger stays in the inward position. If the millivoltage output drops off due to a poor _____, deteriorated thermocouple or thermopile, or pilot outage, the force of the dropout spring will exceed that of the _____ and the disc is forced into the outward position. This movement is used in a valve type Pilotstat design to _____ _____ or in an electric switch type to _____ _____

39 Describe briefly the action of an electric switch type Pilotstat when the reset button is depressed . . .

A valve type Pilotstat?

40 What two basic functions does the Pilot Burner Assembly perform?

a.

b.

41 What is a "non-primary" aerated pilot burner?

42 a. Why are Left- and Right-hand flame patterns sometimes necessary?

b. Which test likely would be flunked if these special flame patterns were not used? _____

_____

43 a. How much of thermocouple or generator tip should be enveloped by the pilot flame? _____

b. Assume everything operating okay but pilot is left over-gassed. What is important objection? _____

_____

_____

44 What are the most common causes of the following poor flame conditions:

a. Lazy yellow: 1. _____
2. _____
3. _____

b. Waving blue: 1. _____
2. _____

c. Small blue: 1. _____
2. _____
3. _____
4. _____
5. _____

d. Noisy, lifting, blowing: _____

e. Hard sharp: _____
But is characteristic of what type of gas? _____

_____

_____

45 Under what four conditions would you consider building a protecting baffle or shield around the pilot?

1. _____
2. _____
3. _____
4. _____

What is the most important requirement relative to the physical mounting of the pilot burner.

_____
_____
_____
_____
_____
_____

46 What symptoms might indicate a clogged or restricted flue pipe?

_____
_____
_____
_____

47 What are some of the characteristics of excessive primary air?

_____
_____
_____
_____

48 What problems would you suspect on a system that was subject to repeated thermocouple failures? _____
_____
_____
_____

50 On a complaint of not enough heat, what type of problem would you look for at the thermostat? _____

51 What problems might you suspect if only one area of the house is underheated? _____

52 What thermostat problems might you look for if the heating system is cycling too rapidly? _____

53 On a job that is subject to fairly wide swings in temperature, you notice that the system is considerably too large for the size of the house in which it is installed. How might you use the adjustable heat anticipation feature of the thermostat to lessen the temperature overshoot at the end of each call for heat? _____

54 If a pilot burner is misapplied in such a way that the pilot flame envelops too great a portion of the thermocouple, what effect would you expect this to have on the open circuit check if any? _____

Why? _____ 198

55 How many possible causes can you think of for a system cycling off the high limit? _____

56 On a complete shutoff Powerpile [illegible]powered gas system the pilot is lit when you arrive on the job. The gas valve does not open when the thermostat calls for heat. Where might there be trouble besides in the temperature control circuit? _____

57 When you arrive on a job, the pilot is out. When relit with the gas cock knob held in, the pilot flame is very small and blue; the pilot goes out when the gas cock knob is released. What are some of the troubles that could cause this? _____

58. Explain how improper installation of the bleed tube on a diaphragm type valve may prevent the valve from opening? _____

Unit 16 - Quiz #2 Name_____

Given the Formula: $T = \frac{3600 \times h}{I}$

Where T = time for one cubic foot of gas flows through meter

h = Average heating valve of gas in BTU per cubic foot

I = Required input to the unit in BTUh

SHOW ALL WORK. COMPLETE THE FOLLOWING:

1. If you have installed a furnace rated at 120,000 BTU input, you call the gas company and find that the heating value of your gas is 980 BTU cu.ft. How long will it take a 1/2 cu.ft. dial to make one revolution?

2. With a 200,000 BTU furnace and a heating value of 1100. How long will it take for a 1 cu.ft. dial to make a revolution?

Given the Formula: $\frac{BTU}{HR} \quad \frac{3600 \times HV}{X}$

Where $\frac{BTU}{HR}$ is how many BTU's you are using an hour.

HV - Is heating value of gas given to you by your gas company

X = Time in seconds for one cubic foot of gas to be consumed. Which is read at meter and time.

SHOW ALL WORK. COMPLETE THE FOLLOWING:

3. Given these different gas meter dial sizes and different HV and times, figure out your BTU/HR for each furnace application.

	Dial Size	HV	Time in Seconds
a.	1/2 cu.ft.	1000	15
b.	1 cu.ft.	900	40
c.	1/4 cu.ft.	1200	7
d.	2 cu.ft.	1100	60
e.	5 cu.ft.	1050	2 minutes

4. When reading a gas meter, there are normally four dials to read. If the four dials read from left to right 4,5,4,6 What would your meter reading be?

5. Of the four dials, do two turn clockwise and two turns counter clockwise?(yes, no)

6. Explain briefy how a four chambered gas meter works.

7. Draw me a pictorial schematic of how a gas furnace would be wired using a T87F thermostat and fan and limit control. Where the fan is 120v and the limit is 24v.

   Show: transformer, fan and limit, gas valve, fuse and on/off switch,

   thermostat, fan motor

8. Draw a double pole double throw relay. Now tie into this relay a 2 speed motor, a humidifier, and a air cleaner. The air cleaner should be operative at either speed. The humidifier in slow speed only.

Unit 16 - Final Examination

You are to pick the *BEST* answer to the following questions.

1. The purpose of a gas pressure regulator is:
   a. To keep the color of the flame constant.
   b. To keep the limit switch from tripping out.
   c. To keep the fan switch from rapid cycling.
   d. To maintain an even room temperature.
   e. To maintain a constant gas pressure at the inlet of the gas valve.

2. L.P. Gas regulators are installed by:
   a. Anyone with the proper tools.
   b. The homeowner.
   c. The general serviceman.
   d. The supplier of the L.P. tank.
   e. All of the above.

3. In a gas pressure regulator, the closing force is controlled by:
   a. The adjustable spring above the diaphragm.
   b. The pressure under the diaphragm.
   c. The inlet pressure to the regulator.
   d. All of the above.
   e. None of the above.

4. In a gas pressure regulator, the opening force is controlled by:
   a. The adjustable spring above the diaphragm.
   b. The pressure under the diaphragm.
   c. The inlet pressure to the regulator.
   d. The outlet pressure to the regulator.
   e. None of the above.

5. The gas pressure regulator will be in equilibrium when:
   a. When the opening force of the spring is equal to the closing force of the inlet gas pressure.
   b. When the closing force of the spring is equal to the inlet gas pressure.
   c. When the closing force of the spring is equal to the opening force of the outlet gas pressure.
   d. When the spring pressure is equal to the inlet gas pressure.
   e. When the opening force of the spring is equal to the closing force of the outlet gas pressure.

6. The vent opening on the gas regulator is called:
   a. Hole
   b. Manifold
   c. Speed
   d. Limiting orifice
   e. All of the above

7. The instrument used to measure the outlet gas pressure is called:
   a. A velometer
   b. An anomometer
   c. A manometer
   d. A tryometer
   e. None of the above.

8. A natural gas regulator should be adjusted to supply _____ inches of water column at the furnace:
   a. Nine
   b. Seven
   c. Five
   d. Three
   e. Two

9. L.P. gas regulators are installed on the tank by the supplier and pre-set at _____ inches of water column:
   a. Eleven
   b. Nine
   c. Seven
   d. Five
   e. Three

10. The 100% shutoff valve has (A) (AN) _____ safety valve and is used with a thermocouple pilot.
   a. Dual purpose
   b. 24 volts
   c. Line voltage
   d. External
   e. Internal

11. The non-100% shutoff valve differs with the 100% shutoff valve because it does not use the:
   a. High limit switch
   b. Thermopile
   c. Semi-automatic safety valve
   d. Internal safety valve
   e. External safety device

12. The magnetic diaphragm valve uses the _____ _____ as a primary force to open and close the valve:
   a. Solenoid pressure
   b. Diaphragm pressure
   c. Gas pressure
   d. Spring pressure
   e. Bimetal pressure

13. The heat motor valve used the principle of using heat given off by an electric heating coil to:
   a. Move an expandable rod.
   b. Energize a solenoid.
   c. Close the valve.
   d. Relieve excess gas pressure.
   e. Control the pilot.

14. On a two stage valve, the low fire position is usually _____ of normal input.
   a. 25%
   b. 30%
   c. 50%
   d. 75%
   e. 80%

15. In check gas valves, one of the faults is more dangerous than all the rest. That is:
   a. Valve stuck open.
   b. Valve stuck closed.
   c. Solenoid coil open.
   d. Solenoid shorted.
   e. Valve won't operate.

16. The most common type pilot used on residential type furnaces is:
   a. The millivolt thermocouple.
   b. The thermopile.
   c. The bimetallic.
   d. The liquid filled.
   e. All of the above.

17. The metal thermocouple has two dissimilar metals welded together at one end. The welded joint is called:
   a. Welded joint.
   b. Hot junction.
   c. Output side.
   d. Cold junction.
   e. Junction end.

18. The electrical energy produced in a thermocouple is measured in:
   a. The range of 12 volts.
   b. The range of 24 volts.
   c. The range of 25 millivolts.
   d. The range of 350 millivolts.
   e. The range of 750 millivolts.

19. The fan switch in the furnace bonnet is designed to:
a. Change speeds in the motor.
b. Cool the pilot bimetal.
c. Control the burner flame.
d. Start and stop the motor.
e. Bypass the thermostat.

20. In a fan switch, the differential is referred to as:
a. The difference between the *on* setting of the fan and the limit switch cutout.
b. The difference between the *off* setting of the fan and the limit switch cutout.
c. The difference between the *on* and *off* setting of the fan.
d. The difference between the *on* setting and the temperature of the room.
e. The difference between the *off* setting and the temperature of the room.

21. A rule of thumb for a fan switch setting is:
a. 10° above the room thermostat setting.
b. 20° above the room thermostat setting.
c. 30° above the room thermostat setting.
d. 40° above the room thermostat setting.
e. 45° above the room thermostat setting.

22. With a time *on*—temperature *off* fan switch the heater is wired:
a. In parallel with the gas valve.
b. In series with the gas valve.
c. In parallel with the thermostat heat contacts.
d. In series with the thermostat heat contacts.
e. In series with the pilot control.

23. The limit switch in the bonnet of the furnace controls the:
a. Pilot ignition.
b. Temperature in the room.
c. Amount of air to the furnace.
d. Amount of gas to the burners.
e. Furnace from overheating.

24. The limit switch is wired in series with the:
a. Fan motor.
b. Pilot switch.
c. Thermostat
d. Gas valve.
e. Fan switch.

25. A heat anticipator is wired:
a. In series with the fan switch.
b. In series with the limit switch.
c. In series with the contacts in the thermostat.
d. In parallel with the contacts in the thermostat.
e. In series with the pilot.

26. The term 100% shutoff refers to:
a. The gas to the pressure regulator is shut off.
b. The gas to the burner only is shut off.
c. The gas to the pilot only is shut off.
d. The gas to the main burners and pilot are shut off.
e. The gas to the furnace inlet is shut off.

27. One of the problems with a pilot is a flickering or lifting flame. This usually means:
a. Furnace cycling on limit switch.
b. Fan switch stuck open.
c. Excessive drafts.
d. Not enough combustion air.
e. Thermostat set too high.

28. When checking a thermocouple for an output reading, the proper meter to use is:
a. Amp meter.
b. Millivolt meter.
c. Voltmeter.
d. Ohmmeter.
e. Anemometer.

29. The heat exchanger acts as a:
    a. Combustion chamber.
    b. A place to adjust the gas pressure.
    c. Connection for the supply duct.
    d. Filter rack.
    e. Storage tank.

30. A flue baffle:
    a. Slows down the flow of combustion produced.
    b. Restricts the air flow over the heat exchanger.
    c. Makes the fan motor more efficient.
    d. Regulates the gas flow to the burner.
    e. All of the above.

31. The speed of a belt drive blower can be changed by:
    a. Adjusting the blower pulley.
    b. Changing the motors.
    c. Adjusting the motor pulley.
    d. Changing the blower wheel.
    e. Adjusting one cut-off plate.

32. There are three basic types of forced-air furnaces.
    a. Horizontal, upflow and gravity.
    b. Gravity, upflow and downflow.
    c. Gravity, upflow and horizontal.
    d. Upflow, downflow and horizontal.
    e. Gravity, downflow and horizontal.

33. When installing a furnace, a minimum of _____ in the front must be provided for service.
    a. 25 inches
    b. 30 inches
    c. 20 inches
    d. 15 inches
    e. 10 inches

34. The nameplate on the furnace is a very important item. On it you will find:
    a. The model and serial number.
    b. BTU input and bonnet capacity.
    c. Type of gas used.
    d. Electrical characteristics.
    e. All of the above.

35. The temperature limit switch protects the heat exchanger from overheating. It shuts off the main burner when any of the following occurs.
    a. Dirty filters
    b. Motor failure
    c. Dirty fan
    d. Loose belt
    e. All of the above

36. The time delay fan switch on the furnace does not come on immediately because:
    a. It conserves energy.
    b. To allow heat exchanger to warm up.
    c. Allows the vent system to create a good draft.
    d. The fan is too noisy when the furnace is cold.
    e. Both b & c.

37. On a combination gas valve, you will find:
    a. Manual shut-off for pilot.
    b. Manual shut-off for main burner.
    c. A pressure regulator.
    d. Pilot adjustment.
    e. All of the above.

38. All fuel gases contain atoms. What makes these gases different is:
a. The speed of the atoms in a molecule.
b. The color of the atoms in a molecule.
c. The number of atoms that make up a gas molecule.
d. The shape of the atoms in a molecule.
e. None of the above.

39. If the voltage supplied to the glow coil is too high:
a. The glow coil will burn out.
b. The glow coil will not light the pilot.
c. The transformer will be overloaded.
d. The limit switch will cycle.
e. The gas valve will not operate.

40. When comparing gas with air, they both must:
a. Have the same amount of moisture content.
b. Be in the same container.
c. Contain the same amount of minerals.
d. Be at the same pressure and temperature.
e. None of the above.

41. One BTU is the heat required to raise one pound of water:
a. One foot in the air.
b. Two feet in the air.
c. Three feet in the air.
d. One degree fahrenheit.
e. Two degrees fahrenheit.

42. Since L.P. gas is stored under pressure, much of the gas is:
a. Lighter than air.
b. Not available for use.
c. Not ready for use.
d. Under fire.
e. In liquid form.

43. Liquefied petroleum gases are known as:
a. Propane and butane.
b. Propane and methane.
c. Butane and methane.
d. Propane, butane and methane.
e. None of the above.

44. Fuel gases have always been considered ideal for heating because:
a. They burn completely.
b. They burn cleanly.
c. They burn with a hot flame.
d. They leave little soot or ash.
e. All of the above.

45. Propane, Butane and Natural gas are called:
a. Obsolete gases.
b. Sulpher type gases.
c. Low energy gases.
d. High energy gases.
e. Fuel gases.

46. The greatest potential of energy of the three gases is by using:
a. 50% of methane and 50% butane.
b. 50% of propane and 50% methane.
c. 100% propane.
d. 100% butane.
e. 100% methane.

47 You should never apply joint compound:
a. With a brush.
b. With a stick.
c. To the female threads.
d. To the male threads.
e. With a spoon.

48 It is good practice to wait _____ after purging before attempting to light the pilots.
a. 5 minutes.
b. 3 minutes.
c. 1 minute.
d. 30 seconds.
e. 15 seconds.

49 When checking for leaks in a gas line, you should *never* use:
a. Soap and water.
b. A match or open flame.
c. Water and oil.
d. Oil and soap.
e. All of the above.

50 When testing the pipe lines for leaks, you should never use:
a. Methane.
b. Nitrogen.
c. Oxygen.
d. Air.
e. Inert gas.

51 Whenever condensate may collect in the line, provisions should be made for:
a. A seal.
b. An inverted tee.
c. A U-turn.
d. A sponge.
e. A drip leg.

52 When installing the piping, all pipe must be pitched at least _____ of horizontal run to prevent traps.
a. ⅛ inch for every 15 feet.
b. ¼ inch for every 15 feet.
c. ⅛ inch for every 20 feet.
d. ¼ inch for every 20 feet.
e. ½ inch for every 20 feet.

53 When applying thread compound to a pipe joint, you must apply the compound _____ back from the end of the fitting.
a. 1 inch.
b. ½ inch.
c. Three threads.
d. Two threads.
e. Four threads.

54 The heating value of the gas in your area can be obtained from:
a. The local gas company.
b. The daily newspaper.
c. The manufacturer of the equipment.
d. American Gas Association.
e. Technical publications.

55 The size of the piping depends on the amount of gas to be consumed, the length of piping, the number of fittings, and:
a. The specific gravity of the air.
b. The specific gravity of the gas.
c. The ambient temperature of the air.
d. The ambient temperature of gas piping.
e. All of the above.

56 The installation of all gas piping must:
a. Be all copper tubing.
b. Be all aluminum tubing.
c. Last at least one hundred years.
d. Last the lifetime of the house.
e. Meet all local and national codes.

57 What are the necessary things for combustion to take place?
a. Fuel, water and heat.
b. Heat, air and water.
c. Oxygen, heat and air.
d. Fuel, oxygen and heat.
e. Vent cap, draft diverter and oxygen.

58 What are the basic elements of common fuel gases?
a. Oxygen and carbon dioxide.
b. Carbon and water.
c. Carbon monoxide.
d. Hydrogen and carbon.
e. Odorant and velocity.

59 When does controlled combustion occur?
a. When the primary air is excluded.
b. When the orifice is upstream of the gas valve.
c. When the orifice does not control the gas flow rate.
d. When the gas pressure upstream of the orifice is increased greatly.
e. When fuel gas and air are supplied at proper rates.

60 LP gases have higher heating values than natural gas, therefore, require:
a. More combustion air.
b. Less combustion air.
c. The same amount of combustion air.
d. No combustion air.

61 Air that is premixed with the gas as it enters the burner is called:
a. Primary air
b. Secondary air
c. Tertiary air
d. Excess air

62 The amount of air needed for complete combustion of any gas is approximately:
a. 2 cu. ft. of air for every 12,000 BTUH gas input.
b. 10 cu. ft. of air for every 1000 BTUH gas input.
c. 40 cu. ft. of air for every 5000 BTUH gas input.
d. Vented air in great quantities should be used.
e. No air required.

63 What is one harmful effect of poor ventilation around the furnace?
a. Builds up dust on the furniture.
b. Changes the orifice size.
c. Corrodes the wooden chairs.
d. Reduces the oxygen supply in the air.
e. Milky water from the water tap.

64 Incomplete combustion forms another class of compound what is it?
a. Odorants.
b. Aldehydes.
c. Natural gas.
d. LP gases.
e. Glass

65 What happens if air is contaminated with solvents, chlorine compounds, propellant spray can gases and are drawn into a flame?
a. Corrosion of furnace parts.
b. Acids will not form.
c. Tobacco will form.
d. Heat exchangers are hardened.
e. Vent caps are preserved.

66 What is combustion?
a. An explosion.
b. A reaction of too much air.
c. Rapid oxidation reaction.
d. Not enough air with solid fuel.
e. Too much heat.

67 What is a gas burner?
a. A resistance heater.
b. A humidistat.
c. A device to form the combustion opening.
d. A draft diverter.
e. A device to produce useful heat.

6? A blue flame burner:
a. Is a very complicated device.
b. Gas pressure is very critical.
c. Is a bunsen burner.
d. Uses no air.
e. Uses only one type of gas.

?7 Why are there several color zones in a bunsen burner flame?
a. To form soot that aids in burning.
b. The colors let you know what type of fuel is being used.
c. Each zone represents a stage in burning of the gas.
d. To make the flame look pretty.
e. The outer cone is the first step in burning.

? The additional air supplied to ensure complete combustion is called:
a. Primary air.
b. Compressed air.
c. No air needed.
d. Secondary air.
e. Excess air.

What is flow velocity?
a. Number of BTU's in a pound of air.
b. Speed of gas air mixture flowing from the burner ports.
c. The burning speed of an open flame.
d. The size of the gas pipe.
e. Stability.

72 What is burning speed?
a. The speed of the flame traveling through the gas-air mixture.
b. The air speed.
c. The burner shape.
d. Type of gas and percentage of air makes no difference.
e. A round burner head.

?. Floating flames are dangerous; they produce carbon monoxide and may extinguish themselves. What causes floating flames?
a. Too much primary air reaching the burner.
b. Insufficient air reaching the burner.
c. Too much combustion air.
d. Combustion air grilles too large ... a closet.
e. Because the flame is hard and noisy.

7. Yellow tips and orange-yellow streaks are different, how can you tell?
a. Dust color streaks are paler than true yellow tips.
b. True yellow tips can be eliminated by more primary air. Orange-Yellow streaks cannot.
c. Dust particles have no affect on a flame.
d. Yellow tips will disappear when viewed with tinted glasses.
e. Dust causes true yellow tipping.

75 If safe and efficient combustion is to take place in a burner, we must have:
a. Proper adjustment and be inexpensive.
b. Proper distribution and adjustment.
c. Proper calibration and flame.
d. Proper burner design and adjustment.
e. Proper burner design and be inexpensive.

76 A disadvantage to the primary aerated pilot is:
a. They have a reputation of being short lived.
b. Too expensive to operate.
c. They always burn yellow.
d. They are non-adjustable.
e. Subject to blocking of primary air openings by dirt, dust and lint.

77 The pilot burner's main function is to:
a. Keep the fire chamber warm.
b. Light the main burner.
c. Keep air from entering the main gas line.
d. Save matches.
e. Create light so you can see the burner chamber.

78 Slotted port burners will come in the form of:
a. The cross-slats may be saw cuts in a cast burner body in a sheet metal burner.
b. The slots may be stamped or punched.
c. The slots may be formed by mounting several flat strips of metal in an opening in the top of the burner.
d. Slots may extend along the length of the top surface of a burner.
e. All of the above.

79 What are some of the characteristics that must be designed into a burner?
a. Complete combustion of the gas.
b. Reasonably quiet operation during ignition, burning and extinction.
c. Control over a wide range of burner rate turndown without flashback or flame outage.
d. None of the above.
e. All of the above.

80 Why is it necessary to have a shutter or some other device in the air opening of a burner?
a. It takes the place of a gas meter.
b. It makes the burner stronger.
c. To catch all the lint and dust.
d. To adjust the size of the air openings to control primary air flow.
e. The burner would collapse.

81 What can happen if you replace an orifice not recommended by the manufacturer's size?
a. It will form a burr in the orifice opening.
b. It will underrate or overrate the furnace.
c. You will have to use a different fuel.
d. The flame will fluctuate.
e. It will change the gas pressure coming to the furnace.

82 Since an orifice is not considered part of the burner, what is an orifice?
a. An air shutter.
b. The first bend in the gas manifold.
c. A gas shutoff valve.
d. A diaphragm.
e. A hole or an opening and contained by a spud.

83 A commonly used instrument to measure gas pressure in a main gas valve or manifold is called:
a. Velometer.
b. Thermometer.
c. Anemometer.
d. Velocity meter.
e. U-Tube manometer.

84 To calculate the CFM by the temperature rise method, you must know 3 items; they are:
a. The temperature rise, BTU input and the ambient temperature.
b. The temperature rise, the fan speed and the ambient temperature.
c. The temperature rise, the BTU input and the fan speed.
d. The temperature rise, the BTU input and cubic feet of gas used.
e. The temperature rise, the BTU input and the efficiency.

85 If the flue draft is not working properly, the flame may be smothered and _____ _____ will be produced.
a. Carbon dioxide.
b. Carbon monoxide.
c. Carbon tetrachloride.
d. Carbon atoms.
e. Carbon molecules.

86 Gas burning equipment should always be capable of:
a. 65% combustion efficiency.
b. 70% combustion efficiency.
c. 75% combustion efficiency.
d. 85% combustion efficiency.
e. 90% combustion efficiency.

87 When making a combustion test on a cold furnace, you should start the furnace and let it run for at least:
a. 10 min.
b. 20 min.
c. 5 min.
d. 2 min.
e. 25 min.

88 Increasing the air shutter opening of a burner:
a. Increases the gas velocity.
b. Decreases the gas velocity.
c. Does not affect the flame.
d. Increases the amount of primary air.
e. Decreases the amount of primary air.

89 No air adjustments to the burners should be made until the burners have been on at least:
a. 5 min.
b. 8 min.
c. 10 min.
d. 12 min.
e. 15 min.

90 Under normal conditions on a U-tube manometer, the manifold pressure will usually be between:
a. 2.0 and 2.5 inches of water column.
b. 2.5 and 3.0 inches of water column.
c. 3.0 and 4.0 inches of water column.
d. 4.0 and 5.0 inches of water column.
e. 5.0 and 6.0 inches of water column.

91 Ratings on furnaces when applied to elevations above 2000 feet should be reduced at the rate of:
a. 4% for each 1000 ft. above sea level.
b. 1% for each 4000 ft. above sea level.
c. 6% for each 3000 ft. above sea level.
d. 3% for each 6000 ft. above sea level.
e. 2% for each 4000 ft. above sea level.

92 For satisfactory operation of a furnace at higher altitudes:
a. The gas input rate should be increased.
b. The gas input rate should be reduced.
c. The burner flame should be increased.
d. The furnace fan speed should be increased.
e. The furnace fan speed should be reduced.

93 Yellow tipping is caused by:
a. A mis-aligned pilot.
b. Too much draft.
c. A defective gas valve.
d. Lack of secondary air.
e. Lack of primary air.

94 If flashback occurs with the burner valve in the off position, the valve probably is leaking or:
a. The pilot light may be burning too high.
b. The pilot light may be burning too low.
c. The pilot safety switch may be bad.
d. The fan switch may be bad.
e. The valve may be installed backwards.

95 On flashback the burning inside the mixer tube does not get enough air. Complete combustion is not reached, producing:
a. Carbon monoxide.
b. Carbon dioxide.
c. Carbon disulphide.
d. Carbon tetrachloride.
e. Carbonic acid.

96 Flashback occurs when the flow velocity of gas-air mixture from the burner port is:
a. Higher than the burning speed.
b. Lower than the burning speed.
c. Higher than the speed of sound.
d. Lower than the speed of sound.
e. Faster than a speeding bullet.

97 One cause for fluctuating flames is:
a. Blower motor going too slow.
b. Furnace too large for house.
c. Unstable gas pressures.
d. Thermostat set too high.
e. Thermostat set too low.

98 When reducing primary air to correct for lifting flames, be sure it is not reduced too much as to cause:
a. The limit switch to trip.
b. The fan switch to trip.
c. Yellow tipping of flame.
d. The fan motor to overheat.
e. The thermostat anticipator to fail.

99 The words "extinction pop" refer to:
a. The noise the gas valve makes when it shuts off.
b. The noise the fan switch makes when it shuts off.
c. The noise the high limit switch makes when it cuts off.
d. An explosion of gas in the burner head when the gas is shut off.
e. The expansion of the metal in the heat exchanger.

100 The simplest way to stop flames from lifting is:
a. To slow down the blower speed.
b. To increase the blower speed.
c. To increase the size of the vent pipe.
d. To reduce primary air.
e. To increase primary air.

AREA - BACK UP HEATING SYSTEMS

Unit 17 - Oil Heating

I. Instructional Objectives
Student will learn thorough understanding of oil heating systems. Student will learn all controls and safeties, proper procedures used in diagnosing and correcting service problems.

II. Reference Material
Domestic and Commerical Oil Burners, all
A Total Look at Oil Burner Nozzels, all
Comfort Heating 4, 5, 6, 13
Honeywell Oil Controls, all
Professional Serviceman's Guide to Oil Heat Savings

III. Visual Aids
Slides, Carrier GTA Oil Burners and Combusion Test
Overheads Honeywell Oil Controls

IV. Method Performance Conditions
Given oil burners and all controls and fire pot construct in lab burner system. Given different makes and models of oil furnaces.

V. Outline

1. Types of burners
2. Determining B.P.H. rate
   A. nozzels
3. Automatic oil burner controls
4. Oil burner wiring
5. Servicing
   A. primary
   B. CAD cell controls
6. Annual service required
7. Adjusting combustion efficiency
8. Ignition and pump problems
9. Basic burner service methods

10. Combustion problems - pulsations

Sample Outline

Week	Subject Matter	Text Reference
1	Types of burners and firing	Ch. 1-6, 23
2	Determining G.P.H. rate and efficience	Ch. 7, 21, 22
3	Oil burner wiring	Ch. 12, 13, 14, 15
4	Primary and cad cell installation & service	Ch. 34
5	Total control systems	Ch. 16-20
6	Review Mid Quarter, Test	
7	Annual service	Ch. 30-32
8	Ignition, pump, nozzle & transformer problems	Ch. 24-26
9	Holiday	
10	Combustion problems, vibrations & pulsation	Ch. 27, 28
11	Review and final	

Assignment Dates

Questions, page 127-128	10-5
Questions, page 377	10-12
Question, page 136-504	10-26
Questions, page 447, 461, 469	11-16
Questions, pages 428-436	12-7

Assignments will be accepted only on dates listed.

Quiz Dates

10-19	4 week	5 questions
11-16	8 week	5 questions
12-3	10 week	5 questions

Sample Outline Continued

Testing: All quiz, mid-term, and final test questions will be developed from the lectures, lab work and home assignments. Please review questions at the end of each chapter you read even though they may not be part of the written assignment. Quizzes, mid-term and final exam must be taken on dates shown, unless previously arranged with the instructor.

Grading:	Assignments	20%
	Quizzes	20%
	Mid and final exams	40%
	Lab Projects	20%

VI. Student Evaluation Parameters

Student will demonstrate proper safety, installation, servicing and maintenance techniques. Student will use all necessary meters to test and set up efficient oil burner operation, combustion efficiency test kit, pressure gauges, transformer test meter, nozzle gauge and remover.

VII. Sequence of Instruction

1. Read all reference materials.
2. View visual aids
3. Discuss safety, installation and service procedures.
4. Student will perform lab projects.
5. Take all unit tests.

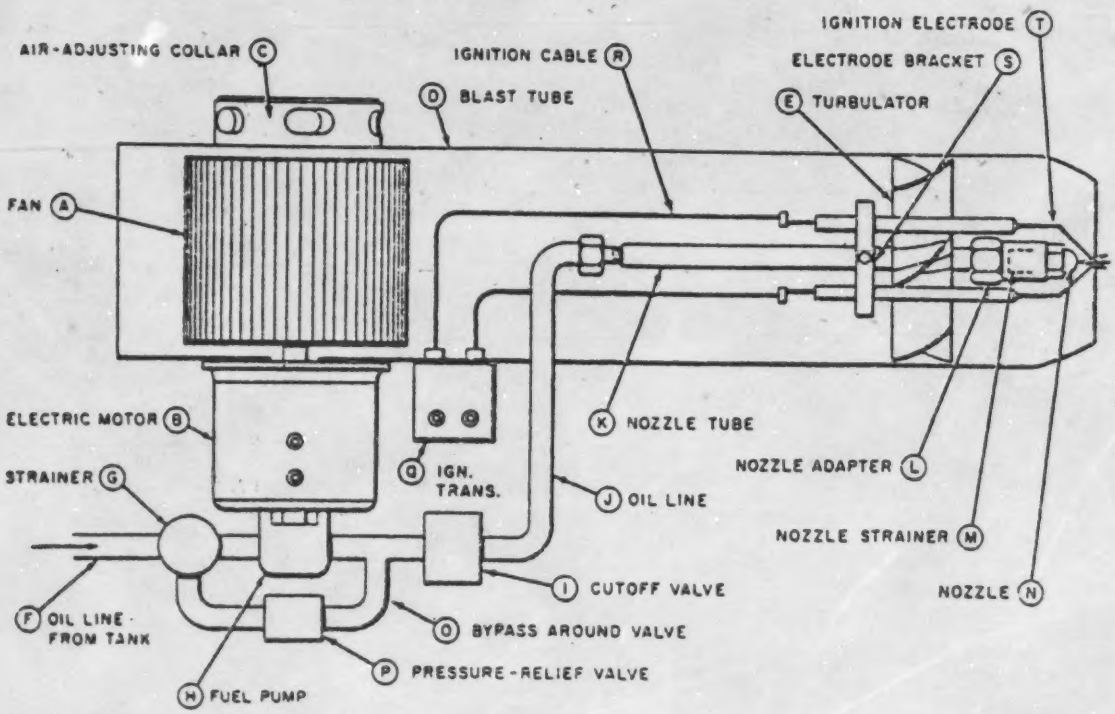
NAME _____

Unit 17 - Quiz

1. There are two basic types of oil burners—determined by the method used to prepare the fuel for combustion. These are the _____ type and the _____ type burners.
2. Of these, only the _____ type uses a conventional automatic control system.
3. Atomizing type burners are in turn divided into two types—rotary and gun type burners. Complete the following table checking the features of each type.

	Rotary type	Gun type
fuel atomized by a nozzle		
fuel atomized by centrifugal force		
electric spark ignition		
primary air blower		
fuel delivered under pressure		

4. The most common type for residential applications is the _____ burner.
5. Fuel in the gun type burner is delivered under high pressure and mixed with air after it goes through the nozzle. How does a low pressure gun burner differ from this? _____



6. Referring to the illustration above, write in the correct order of letters that indicate the flow of oil from the fuel tank to the point of combustion.

_____

_____

7. The electric motor drives both the _____ and the _____.
8. The pressure relief valve is included to permit fuel to flow from the pump, through the bypass, and back to the pump inlet. Why? _____

_____

9. The cutoff valve closes instantly when the motor is de-energized to prevent supplying oil to the nozzle at too low a pressure, the result of which would be

_____

_____

10. The cutoff valve is electrically controlled—the pressure relief valve is controlled by a calibrated _____. (These two valves may incorporated in a single pressure regulating valve).
11. What is the purpose of the turbulator? _____

_____

_____

12. There are three basic controls that must be incorporated in each system—
    a. _____ transmits the need for heat to the primary control.
    b. _____ protects the system from overheating.
    c. _____ supervises the burner under control of the _____ and subordinate to _____.
13. Limit action must _____.
    On limit action the control should/should not (circle correct word) lock out on safety.
14. The type of limit used is determined by the type of system. Basically limits respond to changes in air temperature, _____ temperature, or _____ pressure.
15. Other controls are included as required by the operations to be performed. Briefly state the function of each of the following controls.
    Low limit _____

    Circulator control _____

    Fan control _____

    Switching relay _____
16. The function of the warm air limit in a warm air system is comparable to the function of the _____ in a hydronic system.
17. The function of the fan control is comparable to the _____ control in the hydronic system.

18. The primary control, regardless of type, has three basic functions:
    a. It must respond to heating requirements initiated by the _____ _____.
    b. It must _____ the burner on limit action.
    c. It must supervise the _____, _____, and running of the burner.

19. In order to carry out these functions the control must be able to:
    a. Prove the presence or absence of _____.
    b. Control the _____ transformer.
    c. Shutdown the system on malfunctions such as _____, _____ or _____.

20. Auxiliary functions may also be included in the primary control. An example of this would be _____ _____.

21. The primary control uses the flame detector to sense the flame. These are of two types:
    Thermal—responds to _____ _____
    Visual—responds to _____ _____

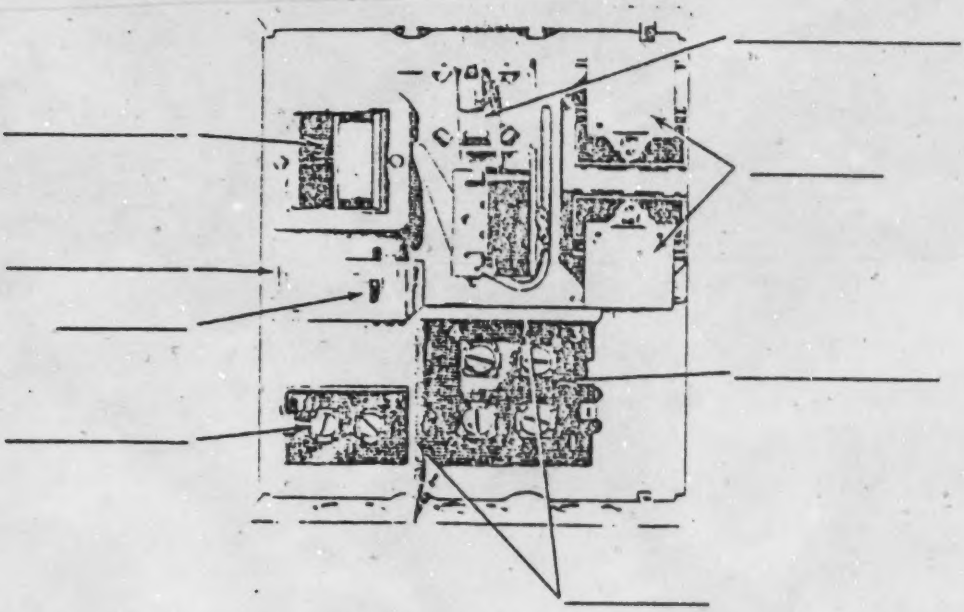
22. The primary control uses the information from the flame detector to either shutdown the burner or to let it run. If flame is proved, the primary bypasses the safety switch—if flame is not proved the safety switch shuts down the system. Answer these questions about the safety switch.
    a. The safety switch has a small _____ element.
    b. What is the action of this element as current passes through it? _____ _____
    c. What must be done before restarting the system if the safety switch trips? _____ _____
    d. Explain how short cycling of a system can cause heat to accumulate in the safety switch and eventually cause a shutdown. _____ _____ _____

23. The type of flame detection used determines the type of primary control. Primary controls using thermal detectors are divided into one and two piece controls. Explain these terms _____

_____

_____

24. The figure below shows a typical stack mounted primary control. Identify the parts indicated.



25. Note terminal four on this control. What does this tell you about the control? _____

26. There are two relays—one controls _____, the other controls _____.

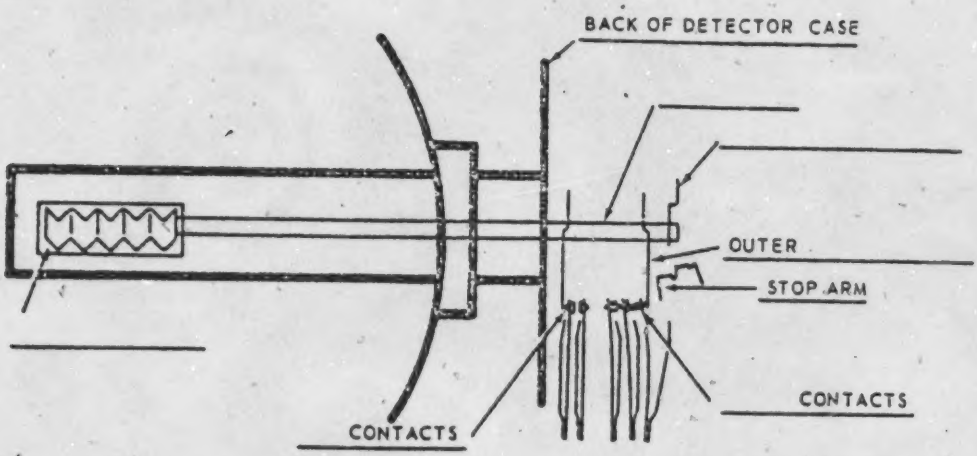
_____ _____

27. What is the purpose of the flame detector in an oil burner system?

28. There are two methods of detecting the flame used in oil systems —visual and thermal. Visual detectors sense _____ emitted from the flame. Thermal detectors respond to an increase or decrease in _____ through a _____ element inserted in the stack.

29. Thermal detectors may be _____ with the primary control (single piece), or _____ from the primary control (two piece).

30. Whether the detector is included with the primary or separate from it, it is basically the same device. Identify the parts of the generalized detector drawn below.



31. Explain briefly the action of the flame detector on an increase in stack temperature.

32. The movement of the bimetal is transferred to the contacts by the _____.

33. Explain the purpose of the stop arm.

34. Most Pyrostat detectors have two sets of contacts as shown in the figure. In a detector such as the C550D which has only one set of contacts, these are normally _____.

35. Pyrostat detectors are normally mounted on the stack _____ any draft regulator. Maximum temperature allowed for most detectors is _____ F. The main requirement in location is that there be sufficient heat to _____

36. Where might the detector be mounted in a system with low stack temperatures? _____

37. If it is necessary to locate the detector at an elbow, into what part of the duct would you insert the bimetal element? _____

38. After a long period of idleness the flame detector contacts may get _____. This is the purpose of the reset lever.

39. Explain briefly how the Pyrostat contacts are stepped. _____

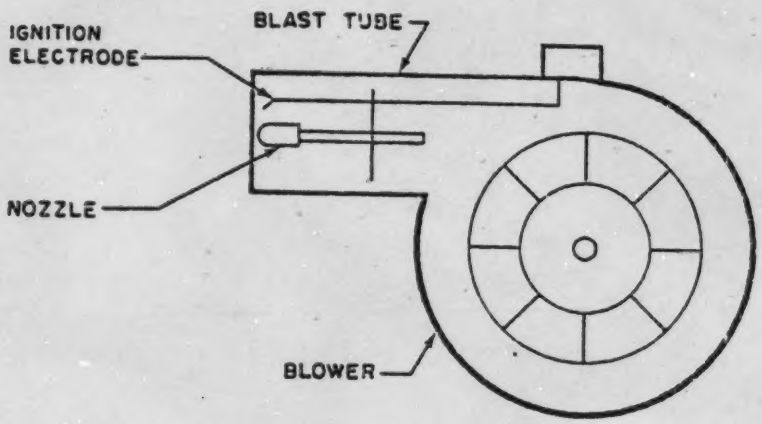
40. The Cad Cell flame detector is a device whose electrical resistance _____ in the presence of certain wave lengths of light energy.

41. What is the main advantage of the Cad Cell over a bimetal stack mounted sensor? _____

42. Does light from the following affect the cad cell?

	Yes	No
Daylight	-	
Incandescent light		
Fluorescent light		
Flashlight		
Match		
Cigarette lighter		

43. Here is a sketch of a burner. Draw in the oil-burner flame, and then draw the Cadmium Sulfide Flame Detector to show it sighting the flame.

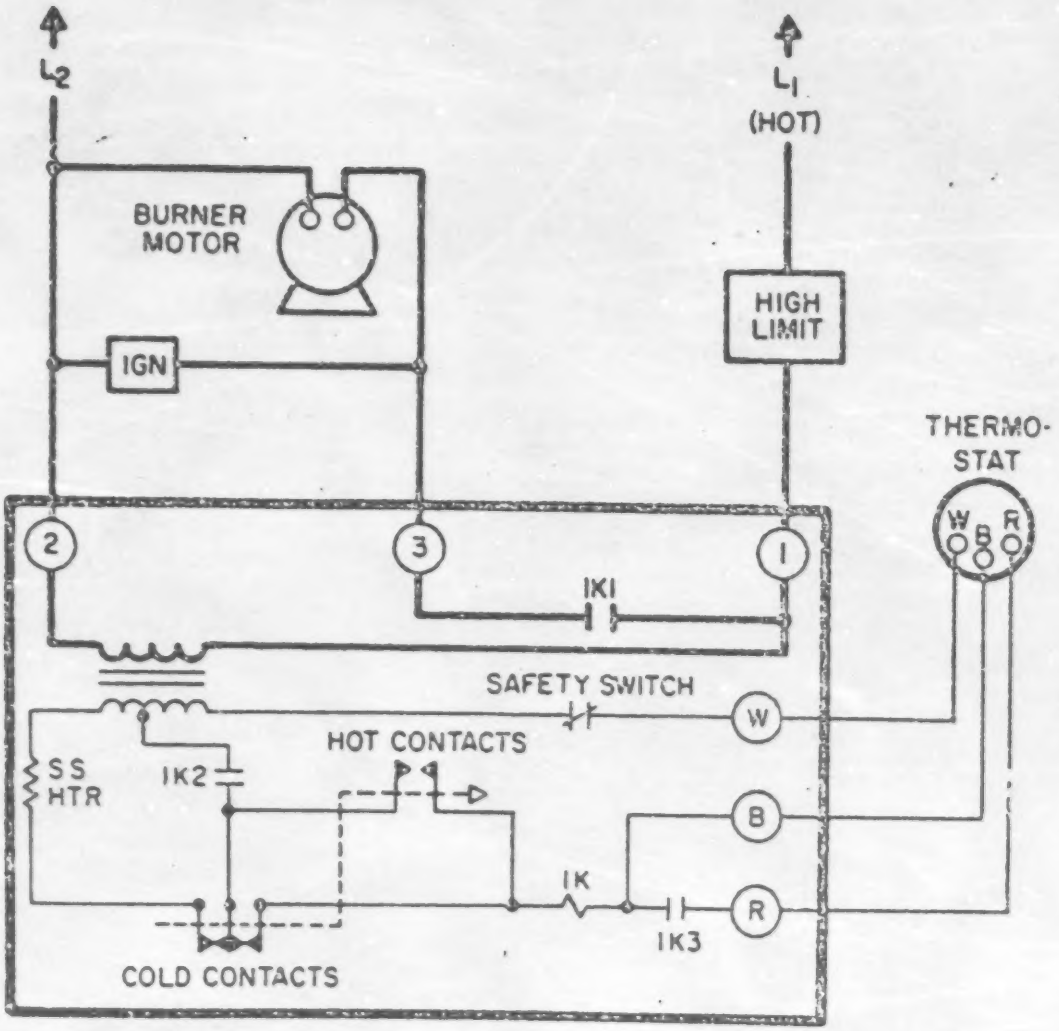


44. List some advantages in mounting the flame detector away from the immediate area of the flame. _____

_____

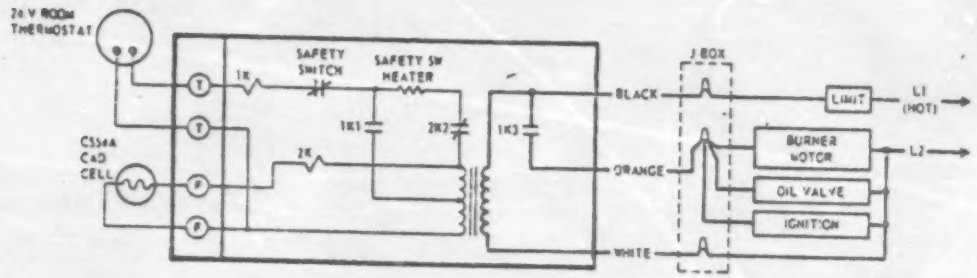
_____

45. The schematic below is a typical stack mounted combination primary control and flame detector. Complete the operation summary in detail to show how the primary and flame detector operate to bypass the safety switch heater.



ACTION	RESPONSE
Thermostat calls for heat	Starting circuit is established through thermostat, 1K, cold contacts, SSH, and safety switch.
1K pulls in	Burner starts, parallel circuit to SSH established through 1K2
Detector senses flame	
OR Detector does not sense flame	

46. Now complete the operation summary for the typical cad cell primary shown below.



ACTION	RESPONSE
Thermostat calls for heat	Starting circuit is established through thermostat, 1K, safety switch, SSH, and 2K2
1K pulls in	Burner starts through 1K3, parallel circuit to SSH is established through 1K1
Cad cell sees flame	
OR Cad cell does not see flame	

46. For each of the three figures that follow, fill in the numbers from the list that correspond to the burner components that must be controlled and their suitable controls.

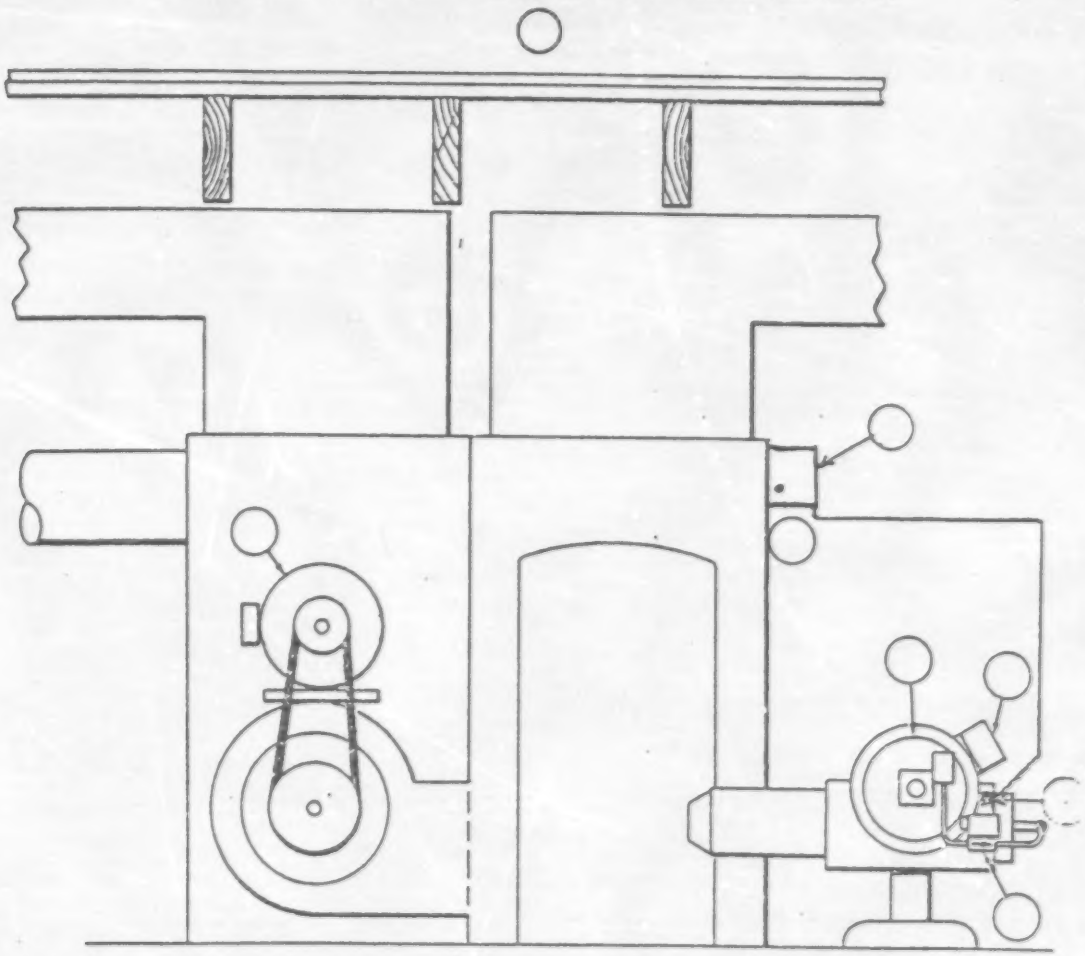
COMPONENTS THAT MUST BE CONTROLLED

1. Burner motor
2. Ignition transformer
3. Fan motor
4. Circulator
5. Oil valve

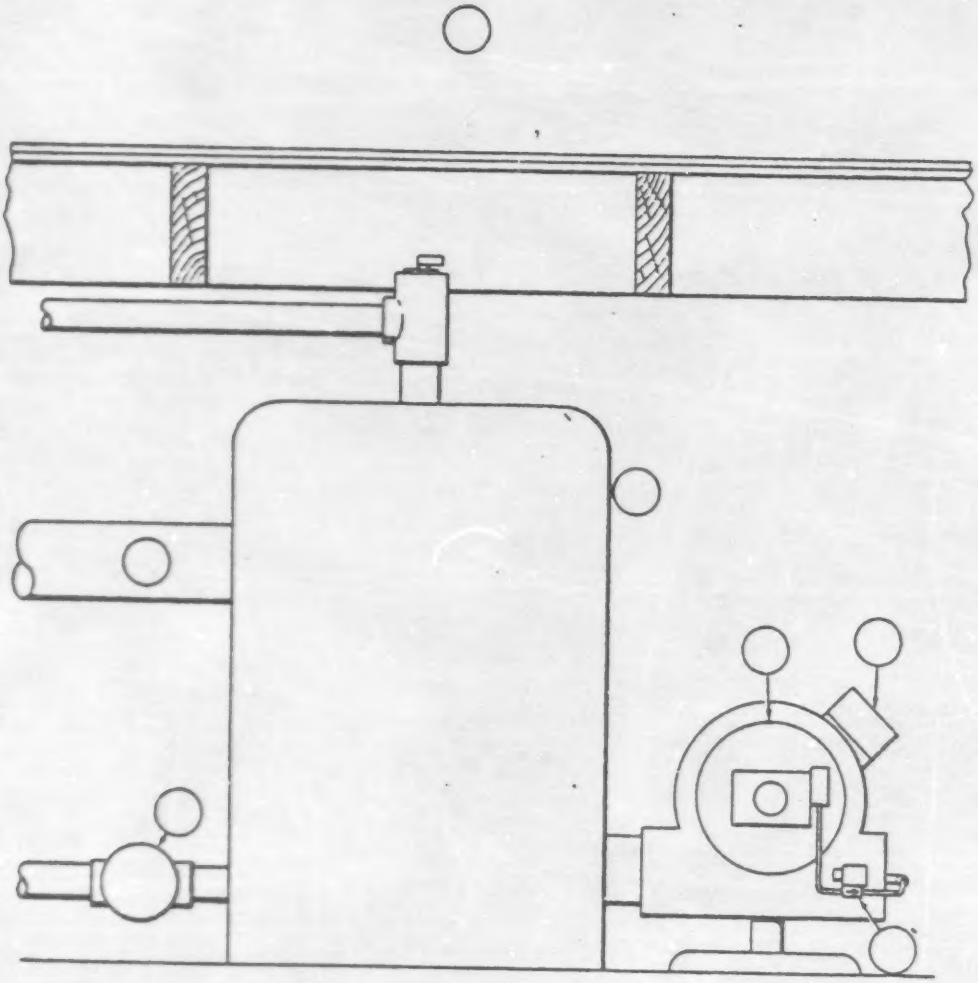
SUITABLE CONTROLS

6. Primary control
7. Flame detector
8. Combination fan and limit control
9. Combination high limit and circulator control
10. Combination high limit, low limit, and circulator control
11. Room thermostat
12. Outdoor thermostat

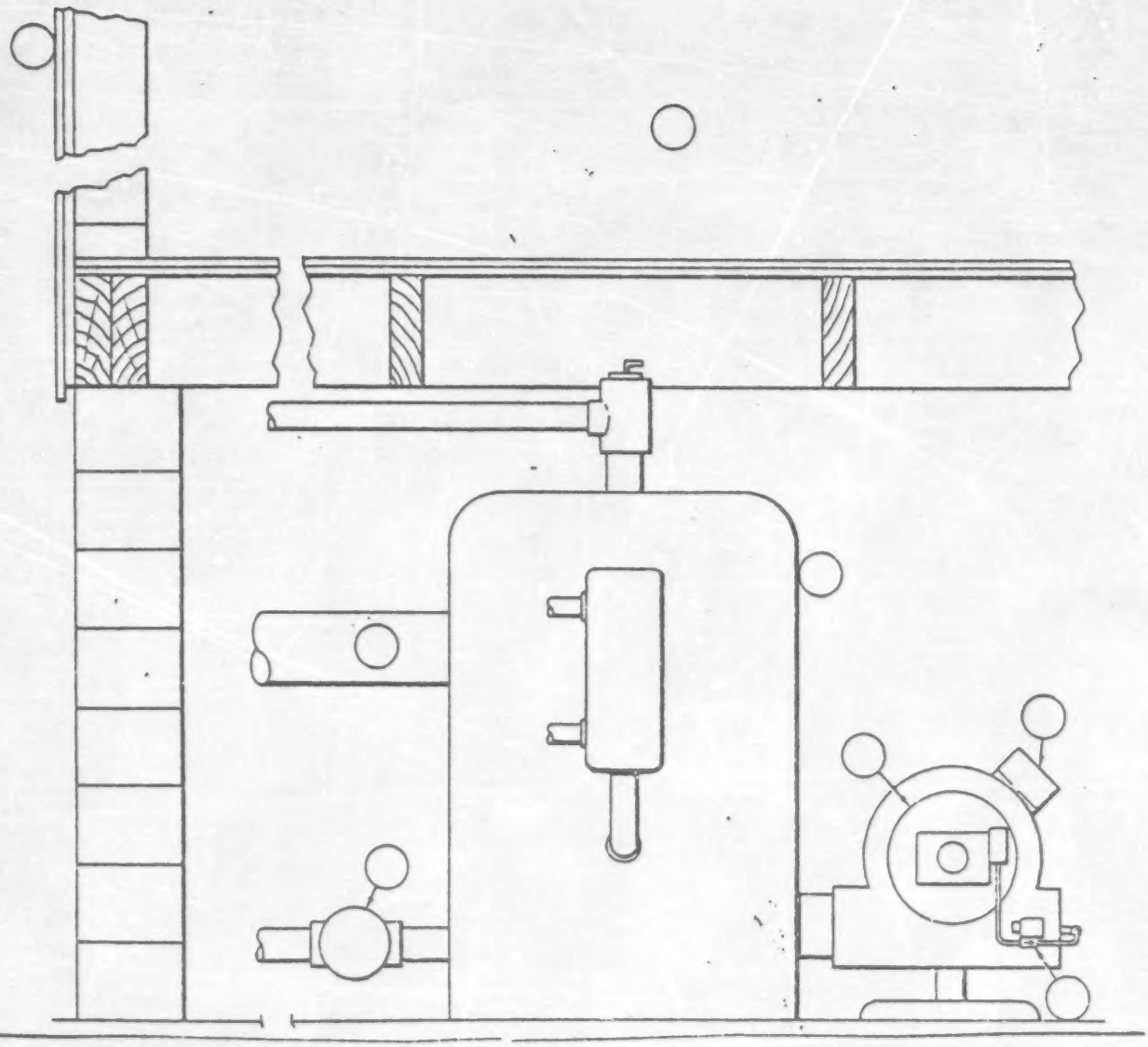
47. - 1. TYPICAL UP-FLOW FORCED-WARM-AIR FURNACE.



42. - 2. TYPICAL FORCED-HYDRONIC HEATING SYSTEM.



49- 3. TYPICAL FORCED-HYDRONIC HEATING SYSTEM WITH DOMESTIC HOT WATER.



50. Why does fuel oil require special lighting equipment?

51. Name three types of fuel oil burners. A.

B. C.

52. At what point in the fuel oil system are the solid particles removed?

53. At what pressure does the regulating valve open?

54. What is the approximate secondary voltage of an ignition transformer?

55. At what pressure does the regulating valve shut off?

56. How is the primary air injected into the fuel oil in the high-pressure fuel oil burner?

57. Name three functions of the atomizing nozzle. A.

B. C.

58. What two types of energy are used in atomizing fuel oil?

A. B.

59. Once a stable spray pattern is established, does it help to increase the pressure?

60. Does an increase in pressure increase or decrease the droplet size?

61. Name two types of cone shapes available with nozzles.

A. B.

62. What is the standard pressure for high-pressure nozzles?

63. Why are small droplets necessary in oil burners?

64. Which cone has a more stable operation under adverse conditions?

65. What nozzle is best suited for use between .4 and 8 ghp?

66. Describe the best flame obtained in burning fuel oil.

67. What is the purpose of the secondary pump in a two-stage pump?

AREA - REFRIGERATION THEORY

Unit 18 - Basic Refrigeration

I. Instructional Objectives

To familiarize the student with proper definitions and terms used in air conditioning. Student will develop an understanding of various comfort conditions and what affects them. Proper use of psychometrics by the service technician will be taught. Student will learn basic heat loss, heat gains dealt with in one industry. Emphasis will be placed on pressures and temperatures as they pertain to boiling liquids and air treatment required for various comfort conditions.

II. Reference Materials

Trane Air Conditioning Manual, 1, 2, 3, 4
Basic Air Conditioning, King. 1, 2, 3, 4, 5, 6, 7
Principles of Refrigeration, 1, 2, 3, 4, 5, 10

III. Visual Aids

Black board: drawing of systems
Overheads of sizing sheets and psychometric
Carrier filmstrip

IV. Method Performance Conditions

Student will be given situations in pressure and latent and sensible changes to work out. Student will be given blueprint of structure and varying air conditions, with psychometric charts and heat loss, heat gain work sheets.

V. Outline

1. Identify and explain the basic parts in the refrigeration cycle.
2. Basic terminology used in refrigeration.
3. Discussion:
   A. temperature
   B. latent heat
   C. pressure
4. Definition of enthalpy
   A. use
   B. heat - transfer

5. Steam tables
6. Body comfort
7. Body comfort - psychometrics
8. Psychometrics
9. Psychometrics and basic load estimation
10. Load estimation

VI. Student Evaluation Parameters

Student will be able to demonstrate an understanding of pressures and temperatures, latent and sensible change. Identify basic parts of refrigeration cycle. Use heat loss/heat gain work sheet and the psychometric chart.

VII. Sequence of Instruction

1. Read all assigned reference materials
2. Work all problems at end of chapters.
3. Work out heat loss/heat gain
4. Demonstrate use with visual aids
5. Work through psychometric problems and plot on charts
6. Take unit tests.

Unit 18 - Sample Problems

1-1. A thermometer reads 34 C. Find the reading of a Fahrenheit thermometer placed alongside of it.

1-2. A thermometer reads 32 F. Find the Centigrade reading.

1-3. How much heat is required to raise the temperature of 12.6 lbs of alcohol from 62 F to 113 F?

1-4. The addition of 1150 Btu to a certain substance raises its temperature from 35 F to 129 F. The weight of the substance is 50 lbs. Find its specific heat.

1-5. An aluminum heating coil weighing 300 lbs is in a room at 55 F. Steam at 2 psig is turned into the coil. How much heat will be required to heat the coil up to steam temperature?

1-6. A heating coil raises the temperature of air flowing through it from 40 F to 110 F. If 400 lbs per min of air flow through the heater, how much heat must be supplied to the air per hour?

1-7. Calcium brine (20 per cent solution) in flowing through an ammonia evaporator is cooled from 45 F to 17 F. If the refrigerating plant can remove 1500 Btum, how many pounds of brine can be cooled per hour?

1-8. 6000 lbs per hr of sodium brine (20 per cent solution) are used to cool 242 lbs of air per min. The temperature of the brine rises from 35 F to 50. If the air enters the cooler at 85 F, what will be its final temperature? There is no condensation of moisture from the air.

1-9. A gage indicates a pressure of 75 psig. Find the absolute pressure in pounds per square inch. Find the absolute pressure in inches of mercury.

1-10. A gage on a tank indicates a vacuum of 12.6 in. of mercury. Find the absolute pressure in inches of mercury.

1-11. A gage on a tank indicates a vacuum of 8in. of mercury. Find the absolute pressure in pounds per square inch.

1-12. The steam gage on a boiler reads 95.6 psig . Find the temperature of the boiling water.

1-13. The gage on a boiler reads 10.9 in. of vacuum. Find the temperature of the boiling water.

1-14. How much heat is required to evaporate 75 lbs of water per hr under a vacuum of 17.72 in. of mercury, if the water enters the boiler at 90 F?

1-15. How much heat is required to evaporate 230 lbs of water per hr under a pressure of 111.3 psig, if the water enters the boiler at 190 F?

Unit 18 - Quiz #1

1. Define B.T.U.

2. Define specific heat.

3. What is hidden heat?

4. Define enthalpy.

5. The gauge on a boiler reads 18 in. hg. What is the abs. in P.S.I.A.?

6. How many B.T.U.s does it take to heat 1 lb. of ice at 20 degrees to steam at 225?

7. What conditions must be present before you can super heat steam?

8. How many B.T.U.'s are there in one ton?

9. What is sensible heat?

10. What is the law for conservation of energy?

11. What is the Fahrenheit reading equivalent to 50 degrees Centigrade?

12. What is the Centigrade reading equivalent to -30 degrees Fahrenheit?

13. Absolute zero on the Fahrenheit scale is_____

14. Zero gauge pressure is equal to what pressure on the absolute pressure scale?

15. A thermometer can sense what kind of heat?

Unit 18 - Quiz #2

TRUE OR FALSE

CIRCLE THE CORRECT ANSWER

T. F. 1. The resistance of a wire on a coil increases as its temperature in lowered.

T. F. 2. A thermocouple consists of two small wires of similar metals fused together at both ends.

T. F. 3. A given amount of mechanical energy can always be converted into exactly the same amount of heat energy.

T. F. 4. Considerable heat can be supplied to a substance during a change of state without the senses being aware of it.

T. F. 5. Heat that changes the temperature of a substance is called latent heat.

T. F. 6. Mercury weighs 12.6 times as much as water.

T. F. 7. If a barometer indicates a pressure of 14.7 psia, a pressure gage beside it will read 1 psig.

T. F. 8. By raising the pressure in a boiler to 52 psig, water can be heated to 300F before it starts to boil.

T.F. 9. Temperature is an indication of the quantity of heat.

T. F. 10. At 450 F the specific weight of steam is 5.55 lb per cu. ft.

FILL IN THE BLANKS

11. _____ can neither be created nor destroyed.

12. The amount of heat required to raise the _____ of one pound of water one degree Fahrenheit is called the _____.

13. _____ is defined as the amount of heat in BTU required to raise one pound of a substance one degree Fahrenheit.

14. The average pressure at sea level is _____ psia.

15. A Pressure of 1 psia is exerted for every _____ in. of mercury. or _____ ft. of water.

16. The _____ _____ of water is not constant; it can be changed at will by changing the _____ above the liquid.

17. The specific weight is the weight of one _____ _____ of a substance.

ANSWER THE QUESTIONS BELOW SHOWING THE STEPS REQUIRED TO ACHIEVE YOUR ANSWER.

18. The initial temperature of the water is 85F, determine the energy required to vaporize 50 gallons of water at a gage pressure of 12.3 PSIG.

19. Answer to the above problem with a gage pressure of 13PSIG.

20. At normal atmospheric pressure 65,000 BTU of heat energy are supplied to 100 lb of water at 162F. What part of the water in pounds will vaporize.

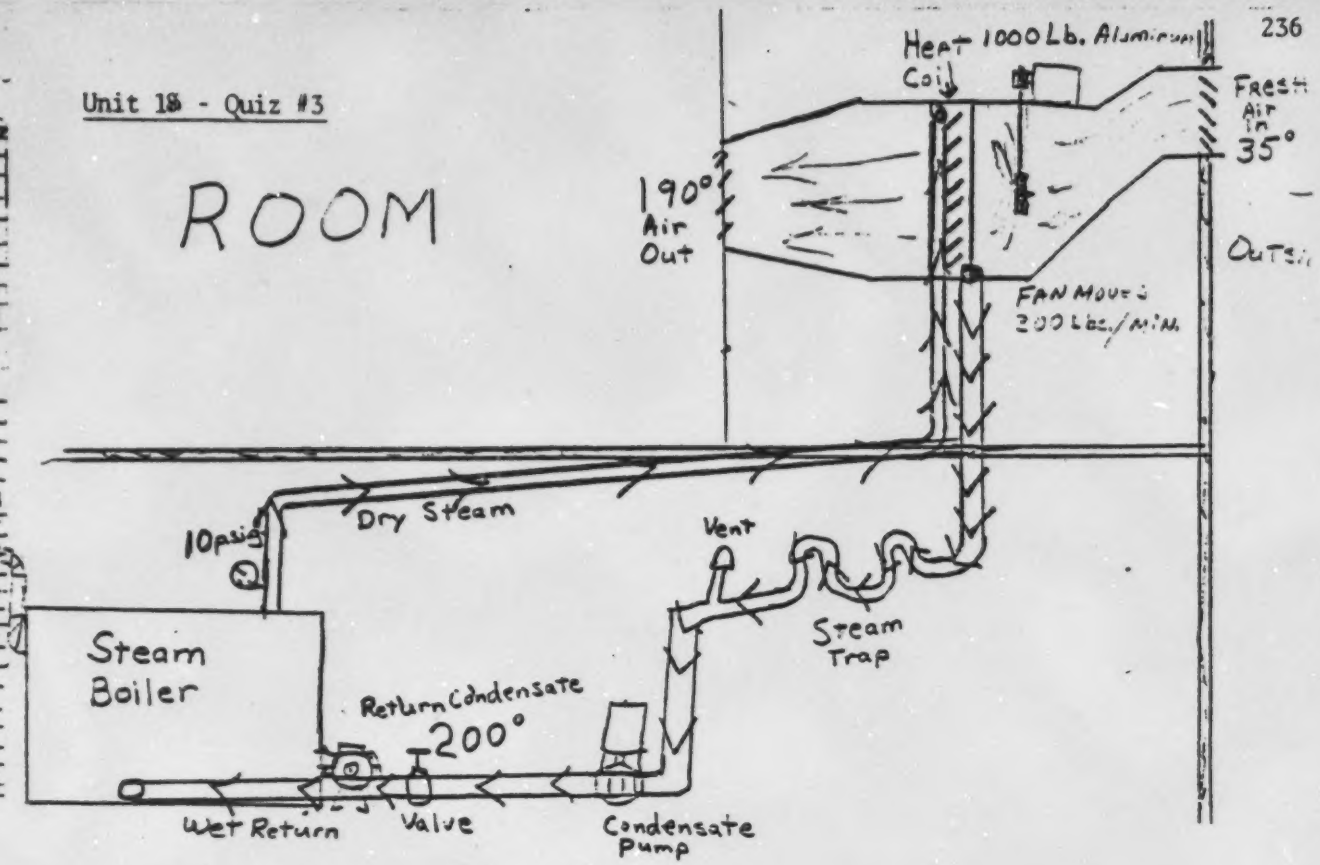
21. 2500 lbs of sodium brine are used to cool 150 lbs of air per min. The temperature of the brine rised from 40F to 60F. If the air enters the cooler at 95F, what will be its final temperature.

22. A gage indicates a pressure of 85 PSIG. Find the absolute pressure in inches of mercury.

23. How much heat is required to evaporate 350 lbs of water hr under a pressure of 113.6 PSIG if the water enters the boiler at 195 F.

24. An Aluminum heating coil weighs 1000 lbs, is in a room at 55 F, steam at 10 psig is turned into the coil; How much heat will be required to heat the coil up to steam temperature.

Unit 18 - Quiz #3



INSTRUCTIONS: Show your work for full credit. If answers only given, NO PARTIAL CREDIT!!!

DRY STEAM ENTERS COIL - SATURATED STEAM LEAVES

1. How many lbs. of steam would be needed to heat the coil from 50° F to steam temperature. (No air going through coil)

2. How many lbs. of steam/hr. would be needed to heat the air? (coil at steam temperature)

3. Condensate enters boiler at 200° and leaves as steam at 10 psig — how many BTU's did the boiler add to 1 lb. of condensate to change back to steam?

4. If one gallon of oil costs 10¢ and gives off 140,000 BTU/ gallon at 100% efficiency, determine the number of gallons of oil consumed per hour at 80% efficiency to make the steam needed to heat the air. If the pump cost 2¢ per hour to operate, the blower fan forcing air through the coil cost 6¢ per hour to operate, the oil burner motor and transformer cost 5¢ per hour to operate. Determine the total cost of operation including the oil consumption per hour.

Select from the statements on the right hand column the best answer for the word on the left hand column. Write the number of the statement in the blank of the left hand column.

_____ Superheat	1. Heat that changes the state but not the temperature.
_____ Density	2. Heat required to meld one pound of ice at 32 degrees F.
_____ Btu	3. Melting point of ice at 0 psig.
_____ -460 Degrees F.	4. Transfer of heat by rays.
_____ Latent Heat	5. Used to indicate pressures above atmosphere.
_____ 32 Degrees F.	6. Heat that changes the temperature of a substance but not its state.
_____ Conduction	7. Weight per unit volume.
_____ Inches of Mercury	8. Volume per unit of weight.
_____ 144 Btu	9. Heat in Btu needed to raise the temperature of 1 (one) pound of substance 1 (one) degree F.
_____ Radiation	10. Transfer of heat within a solid.
_____ 212 Degrees F.	11. Where molecular motion ceases.
_____ Specific Heat	12. Unit of measure of intensity of heat.
_____ Heat	13. Ratio of weight of a substance to a weight of an equal volume of water.
_____ Ton of Refrigeration	14. A form of energy.
_____ Pressure	15. Used to indicate pressures below atmospheric.
_____ PSIG	16. Transfer of heat by fluid currents.
_____ Sensible Heat	17. Force per unit area.
	18. Boiling point of water at 0 psig.
	19. Refrigeration produced by a ton of ice melting in 24 hours.
	20. Heat needed to raise the temperature of 1 (one) pound of water 1 (one) degree F.
	21. Sensible heat added to a gas.